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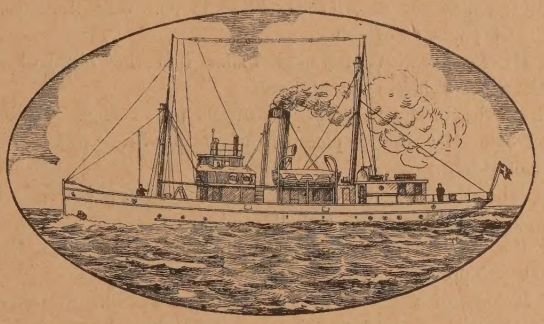

XLI

1936.

By

H. Blegvad, Ph. D.
Director

Copenhagen. C. A. Reitzel.
1936.

The Reports from the Danish Biological Station (Nos. I—XXI) are published in the official Danish "Fiskeri-Beretning" for the years 1890—91 until 1912. After this year they appear as special publications. The Reports I—XXXII are edited by the late Dr. C. G. Joh. Petersen, the Reports XXXIII—XXXVI by Dr. A. C. Johansen and the later Reports by Dr. H. Blegvad.

I. *C. G. Joh. Petersen:* Fiskenes biologiske Forhold i Holbæk Fjord. (1890—91*) 63 pp. 1 Chart. Out of print.

II. *Idem:* On the Eggs and Breeding of our Gobiidæ. (1891—92.) 9 pp. Two Plates. Out of print.

III. *Idem:* The Pelagic Life in Fænø Sound etc. (1892—93.) 38 pp. Tables. Out of print.

IV. *Idem:* On the Biology of our Flat-fishes and on the decrease of our Flat-fish Fisheries. (1893—94.) 146 pp. 2 Plates. 1 Chart. Many Tables. Out of print.

V. *Idem:* The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. (1894—95.) 35 pp. With 2 Plates.
Etc. 64 pp. Out of print.

VI. *Idem:* The Yearly Immigration of young Plaice into the Limfjord etc. (1895—96). 48 pp. 1 Chart. 2 Tables. Out of print.

VII. *Idem:* Plankton-Studies in the Limfjord. 1897. 23 pp. 1 Map. 4 Tables. Out of print.

VIII. *Idem:* An Otter-Seine for the Exploration of Deeper-Seas. 1898. 24 pp. With 10 Figures. Out of print.

IX. *Idem:* Trawlings in the Skager Rack and the Northern Cattegat in 1897 and 98. 1899. 56 pp. With one Map. Out of print.

X. *Idem:* List of the "Aalerusestader" in Denmark etc. — Smaller Communications. 1899 and 1900. 37 pp.

XI. *Idem:* I. The Biology of the Cod in the Danish Seas. II. On other Codfishes in our Seas. III. Some General Observations on Protection, Legislation etc. IV. Alterations and Improvements on Otter-seines for Zoological Purposes. 1900 and 1901. 44 pp.

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XIII. *A. Otterstrøm:* Eggs and Young of Fishes in the Danish Waters. (Investigations during 1904 and earlier years.) 1903 and 1904. 85 pp.

XIV. I. *C. G. Joh. Petersen:* The Influence of Light on the Migrations of the Eel. II. *K. I. Gemzøe:* Age and Rate of Growth of the Eel. 1906. 39 pp.

XV. *Idem:* I. First Report on the Oysters and Oyster Fisheries in the Lim Fjord. (70 pp.) 1908.

XVI. *C. H. Ostenfeld:* On the Ecology and Distribution of the Grass Wrack (*Zostera marina*) in Danish Waters. With 9 figures. 1908. 62 pp.

XVII. *C. G. Joh. Petersen:* II. Second Report on the Oyster and Oyster Fisheries in the Lim Fjord. 1908. (24 pp).

XVIII. *C. G. Joh. Petersen:* I. The Yield of the Limfjord fisheries in recent years and the transplantation of Plaice in 1908. With 6 tables and 1 Chart. II. Biological investigations on the stock of Plaice in the Limfjord. With 3 Tables. III. The Yield of the Prawn fishery from 1885—1907 and its improvement by means of protection. With 3 Tables. 25 pp. 1909.

XIX. *Idem:* Some Experiments on the Possibility of combating the harmful Animals of the Fisheries, especially the Whelks in the Limfjord. 20 pp. 1911.

XX. *C. G. Joh. Petersen* og *P. Boysen Jensen:* Valuation of the Sea. I. Animal Life of the Sea-Bottom, its food and quantity. With 6 Tables, 3 Charts and 6 Plates. 81 pp. 1911.

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*) The figures in ( ) refer to the "Fiskeri-Beretning" for the years quoted.

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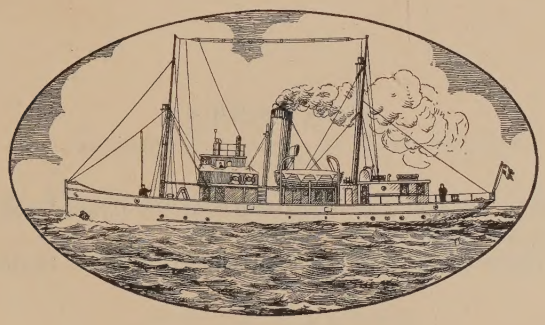

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The Distribution of the Invertebrates in the Dybsø Fjord, Their Biology and Their Importance as Fish Food.

By

KNUD LARSEN

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I. Introduction.

During the time which has passed since the quantitatively inaccurate dredge was superseded by the grab of Dr. C. G. Joh. Petersen in Danish marine investigations our knowledge of the animal life of the sea-bottom has been added to in a very considerable degree. Earlier investigators had confined themselves to a mere carrying down of the species of different areas of water, but now a possibility arose of comparing the quantities of the individual species and, on the basis of such comparisons, of setting up animal communities of the sea. In Dr. Petersen's papers on the animal communities of the Danish waters (1911, 1913) these possibilities were highly utilized and have been of fundamental importance to later marine investigations in this country and abroad.

Of course this radical change from purely qualitative to combined qualitative and quantitative investigations of the animal life of the sea-bottom must necessarily influence the study of the nutrition of the fishes.

Investigations on this subject from before 1911 resemble those on the animal life of the sea-bottom in so far as all species met with were merely carried down, no special regard being paid to their proportionate quantities in the stomach contents of the fish. This is the case with C. G. Joh. Petersen's investigations of the Holbæk Fjord (1890—91) and his investigations on the biology of the flat-fishes (1893—94).

The first quantitative investigations of the stomach contents of fish was in this country carried out by H. Blegvad (1916). This investigation even went a step farther, some regard being paid to the animal communities within the boundaries of which the fish in question are principally living. However, inside different marine areas the same animal community shows a different composition, and so the investigation discusses the quantities of the individual species in the stomach contents, but it does not account for the proportionate quantities of the individual species on the sea-bottom as compared with their proportionate quantities in the stomach contents.

The present paper aims at establishing this proportion as far as the *Macoma baltica* community of the Dybsø Fjord is concerned. Whether the proportion is the same in all compositions of the *Macoma* community must be left undecided until similar investigations have been carried out in other marine areas.

The Dybsø Fjord in the southern part of Sealand is an excellent object of an investigation of this kind. It is a "close" water, that is to say it is well delimitated from the sea outside. Furthermore, it shelters only one animal community, which also inhabits the water outside the Fjord, and so there is but a very small chance of the fish examined having fed on the animals of other communities.

The preparation of the material disclosed some interesting biological features which are dealt with below although they can hardly be said to belong to the proper object of investigation. Consequently, this paper is composed of three principal sections: the composition of the animal community, the biology of the individual species, and, finally, the importance of the species in the diet of the fishes of the Fjord. By means of the first and third section we are able to calculate the proportion between the percentage quantities of the individual species on the sea-bottom and in the fish stomachs.

I regret to say that time has been too short and money insufficient for an exhaustive treatment of the subject. It would be most desirable to extend the investigation to a series of years and all seasons of the year, by which means you would be able to

control the influence of variations in the stock of food animals on the composition of the stomach contents, and to work a larger material of fish. However, this being impossible, I have chosen fairly the same period of the year (spring and early summer) for the various parts of the investigation in order to eliminate the trouble caused by the fluctuations of the stock of food animals.

Certain technical difficulties will be mentioned in their due places.

As to the investigation the procedure was as follows:

In the first place a thing to be learned was the distribution and numerical strength of the food animals of the Fjord. For this purpose 293 bottom samples were taken with the Ekman bottom sampler ($^1/_{44}$ sq. m.) during the period of June, 5th—19th, 1934 on a total of 31 stations and in such a way that varying depths, kinds of bottom, distances from freshwater, etc., were represented. The number of samples taken at each station appear from Table I. Unfortunately, the depth to which this light bottom sampler is able to force its way down proved insufficient for the purpose of catching certain animal species (*Mya*, *Arenicola*), but it was impossible to use the 0.1 sq. m. Petersen grab, for on account of the shallowness of the water the samples had to be taken from a small flat-bottomed rowing boat.

During the same time and for the sake of orientation 14 samples were taken with a fine-meshed dredge through the vegetation in various localities of the Fjord. Being of no quantitative value these samples are not included in the calculations given later in this paper, but they have yielded some biological information.

The quantitative investigations of the epifauna took place during the period of May, 17th—21st, 1935, and was carried out by means of the hand net used for quantitative purposes by C. G. Joh. Petersen (1918).

The material of the bottom samples was preserved immediately to be determined and weighed later on, and so the weight figures of the bottom samples denote the "alcoholic weight". The animals of the hand net samples, however, were weighed alive after the water had been removed by means of filter-paper. After examination the bottom samples were given to the Zoological Museum of Copenhagen whereas the hand net samples were thrown away.

The examinations of the fish stomachs were carried out on April 14th—23rd and July 3rd—10th, 1935. The fish used during the first period had been caught in weals and "Toggergarn" (a kind of setting net), those used during the latter period (principally eel) were taken on hooks or caught by torch-light. It was seen that the fish were caught in different localities, so that all phases of the animal community are represented.

That I have succeeded in the course of so short a time and at so small an expense to carry out an investigation of the present extent is primarily due to the fact that everywhere, both in private persons and official institutions, I have experienced a very great helpfulness. So I wish to return my thanks to Mssrs. Holger and Georg Ambæk, Søren Petersen, and Orla Rasmussen, Fishermen of Basnæs, to my Assistant Gunni Petersen, Taxidermist of Næstved, and to Rev. Valdemar Jensen of Vejlø and his wife for their kindly accepting me in their home during my stays at the Fjord.

The Danish Biological Station has given me valuable assistance in lending me various gears for the investigation. Mr. H. Blegvad, Dr. phil., Director of the Station, and Mssrs. C. V. Otterstrøm, Mag. scient., and E. M. Poulsen, Dr. phil., were always ready to make their great experience useful to me, for which I want to bring them my best thanks.

In the determining of some of the animals collected and the corroborating of my own determinations I was assisted by the Zoological Museum of Copenhagen. I am specially indebted to Mssrs. G. Thorson, Mag. scient., K. Stephensen, cand. mag., Mrs. E. Wesenberg-Lund, Mag. scient., and Mr. P. L. Kramp, Dr. phil. I also want to thank Mr. E. W. Kaiser, stud. mag., who determined the Coleoptera, Trichoptera, and Odonata collected.

I beg to render my special thanks to the Management of the Japetus Steenstrup Fund for finding this paper worthy of the pecuniary support given to me.

Finally, I want to thank my wife, who acted as my secretary and, i. a., has carried out all measurings of the bivalve material collected.

II. General Remarks.

Topography, Depth, Vegetation, Nature of Bottom, Salinity, etc.

The Dybsø Fjord is the southernmost fjord of Smaalandsfarvandet indenting the coast-line near the mouth of the river Susaa. Through the Hestevaad (Figure 1) and the Krageholms Strøm towards the northwest it is connected with the Karrebæk Fjord

The western boundary of the Fjord is made up by the islet of Dybsø and a peninsula of the Svinø Land. Between Dybsø and this peninsula we find the principal connexion of the Fjord with the Svinø Bay (the eastern part of Smaalandshavet), the

Figure 1. Map of the Dybsø Fjord showing the general topography and the situation of the stations. Scale 1:53000. ○ I, ○ II, ○ III, etc.: hand net stations. □ 2, □ 3, □ 4, etc.: bottom sampler stations.

into which the river Susaa falls directly. The quantities of organic matter carried into the Karrebæk Fjord by the river colour the water of this place intensely but settle before reaching the Dybsø Fjord. But in the Hestevaad some slight influence of the freshwater is perceptible, the salinity of the water of this locality being about $^1/_2$ ‰ lower than in the rest of the Fjord apart from the immediate vicinity of the freshwater outfalls.

Dybsø Strøm, forming a channel of about 60 m. in breadth and 2 to 3 m. in depth.

The other connexion between the Fjord and Smaalandshavet is the Hestevaad and the water west of the northern part of the Dybsø. Here the depth does not amount to more than 1.5 m.

Apart from such freshwater of the Susaa as enters into the Hestevaad the outfalls of freshwater into the Fjord amount to three: Kyllebækken in the

eastern part of the Fjord, Basnæsgrøften watering into the creek between Basnæs and Jars Skov, and the canal of Nylands Mølle. Some fountains of the hills round the bay at Svinø Land are of inferior importance.

In former times Vejlegrøften in the south-eastern corner of the Fjord carried considerable quantities of freshwater into the Fjord from the marshes of Køng-Lundby. However, for the purpose of draining the marshes in a southward direction this ditch was filled a short time before the beginning of the present investigation. So we cannot say anything definite about the degree to which this freshwater has influenced the salinity of the inner part of the Fjord in former times.

The area of the Fjord as limited by a line from Vejløgaard to the northern point of Dybsø and another line across the Dybsø Strøm west of Bønvig Gaard, is about 17 sq. kms. Reminiscences of a still larger extent in former days are names like Vejlø, Svinø, and Køng. Through Nylandsmosen in the north the Fjord was openly connected with Fladstrand, through the marshes of Køng-Lundby-Sværdborg in the south with the Agnø Fjord. In the Lundby Mose, where the author got a view of the stratification, the former bottom of the Fjord was situated but fifty odd cms. below the present surface of the ground, directly below the sediments of the "Mullerup Culture".

In the creek of the Dybsø Fjord that separates the Jars Skov from the fields of Vester Egesborg the clotty material of the bottom exhibits impressions of the shells of *Cardium edule* of a size far superior to that of the present specimens of the Fjord. Most probably these impressions date from a time when the connexion with the sea was a more open one than now.

The depths of the Fjord appear from the map

Figure 2. Map showing the depths of the Dybsø Fjord. The curves give the depth in feet (1 foot = 0.3139 metre), the figures show the depth in metres. Scale 1:57000.

(Figure 2). The curves of the Fjord originate from the soundings carried out by the Water Department in 1905, and give the depths in Danish feet below the datum of the General Staff. The curves outside the Fjord are taken from the topographical maps of Næstved and Knudshoved (scale 1:40 000) drawn by the General Staff. The figures in the Fjord state the depths in metres below the surface, measured at the stations of hand net samplings and bottom samplings.

Figure 3. Approximate distribution of the associations of vegetation in the Dybsø Fjord. Scale 1:53000.

Near the middle of the western part of the Fjord there is a stony reef called Rønnen, which is overflown only at very high water. A smaller reef called Lillerønnen, visible above the surface at low tide only, is situated in the narrow part of the Fjord between the Jars peninsula and Svinø Land.

The vegetation appears in three definite communities: a *Chara* community, a *Ruppia* community, and a *Zostera-Fucus* community.

The *Chara* community is by far the largest of the three, covering nearly the whole of the area in which the bottom material consists of pure detritus or detritus mixed with sand (Figure 4). The Characeae often stand very close; in some places they reach a length of more than 1 metre, and in high summer they cover large parts of the surface of the water. Fishermen acquainted with the localities tell that the algae will die on reaching the surface in summer, and that the Fjord is empty at intervals of about 10 years.

The *Ruppia* community is rather small and limited to the area east, south, and southwest of Rønnen. In none of these two communities determinations of species were carried out.

Zostera marina and *Fucus vesiculosus* were not found to grow east of Rønnen. The former, however, is the characteristic plant of the westernmost part of the Fjord, the latter, when occurring inside this area, being always few in number.

Zanichellia sp. have been found in the mouths of Kyllebækken and Vejlegrøften, and throughout the Fjord a green filiform algae occurs.

The nature of the bottom material (Figure 4)

varies with the depth and the conditions of current. Of course detritus plays a principal part in fjords of a rich vegetable life like the Dybsø Fjord, but detritus with no admixture of other elements occurs in few localities only: a small patch in the creek between Jars and Vester Egesborg, another small area situated south of Basnæs and west of the western point of the Jars peninsula, and a larger area northwest of Lillerønnen. Finally, in the southernmost portion of the Fjord, the bay at Svinø Land, a narrow strip of bottom along the coast contains pure detritus.

In nearly all other parts of the Fjord detritus is found, too, but here it is mixed with mineral elements, mostly sand, rarely gravel.

Pure gravel is found only in a small space between between the detritus areas south of Basnæs, pure sand being more commonly met with, especially in localities exposed to currents: a strip along the Jars coast, in the Hestevaad, and a large area in the southwestern part of the Fjord.

Coincidently with the bottom samplings and at the same stations the salinity of the water was determined by means of the araeometer. The figures are given in Table I. Apart from the stations in or near the outfalls of freshwater and in the Hestevaad the average salinity was found to be about 13 $^{0}/_{00}$.

This figure does not agree with the value found by Kramp (1918, p. 318) in Smaalandshavet near Svinø and Karrebæksminde in 1914, viz. 10.5 $^{0}/_{00}$. Probably, this disconformity may be explained for by the very hot and dry weather during the present samplings having caused an intenser evaporation and, consequently, a higher concentration of the water of the Fjord. On certain days the shallow parts of water had a temperature of more than 25° Celsius.

As regards the bottom animals of the Fjord the following will show that the number of individuals are in some localities very large, the number of species, however, being comparatively small as might be expected from the inconsiderable variations in the conditions of existence in a shallow fjord (cp. Johansen, 1914).

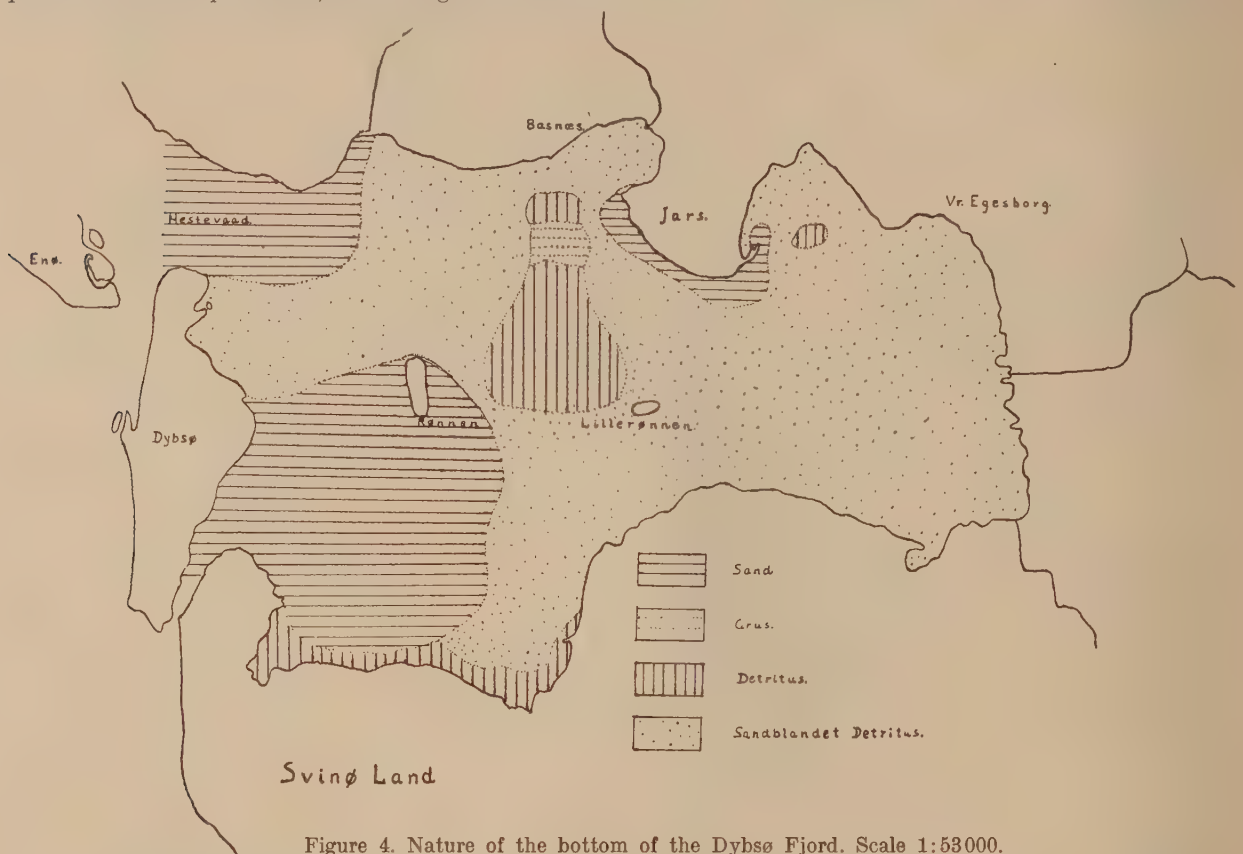

Figure 4. Nature of the bottom of the Dybsø Fjord. Scale 1:53000.

III. Distribution and Biology of the Invertebrates.

In describing the faunistic and biological conditions of the invertebrates of the Fjord I refer to the Tables I and II, which give the contents of the bottom samples and hand net samples.

For the sake of comparison I also give the distribution of some other Danish waters, at the same time generally stating the salinity of the area in question. Most of the material compared was taken from A. C. Johansen, etc. "Randers Fjords Naturhistorie", 1918; A. C. Johansen "Om Forandringer i Ringkøbing Fjords Fauna", 1914; C. G. Joh. Petersen "The Animal Communities of the Sea-Bottom and their Importance for Marine Zoogeography", 1913; and from the still unpublished description of the fauna of the Ringkøbing Fjord, of which separates on the crustaceans and insects were most kindly put at my disposal.

Number and situation of the stations will appear from the map (Figure 1).

A. Bivalves.

1. *Mytilus edulis* L.

Our common mussel (*Mytilus edulis*) is the characteristic animal of the epifauna of the *Macoma baltica* community and is stated (Jensen & Spärck, 1934) to belong to the marine mollusks that are best fitted to suffer brackish water. So one would expect to find it in a fairly uniform distribution all over the Fjord; but this is not the case. Specimens of *Mytilus*, respectively 1, 9, 1, 48, and 1 were found only at bottom sampler stations 19, 20, 21, 24, and 28, 10 samples of $^1/_{44}$ sq. m. apiece being taken at each station. So, in using the bottom samples as a basis of estimating the distribution of this bivalve in the Fjord in an inward direction, we should put the limit at the line Basnæs—Hjortevangsgaard. The hand net samples draw the line a short distance farther eastwards, 2 small specimens (in two samples each of 1 sq. m.) having been taken at hand net station VIII. However, an abundance of *Mytilus* appears in the western part of the Fjord only (hand net stations XIV and XV).

The cause of this limited distribution can only be guessed at. The fact that this bivalve does not advance farther than the entrance of the inner Fjord cannot be put down to a lower salinity of the latter area because a difference in salinity between the outer and the inner Fjord could not be established. Moreover, Johansen (1918) lays down the inner limit of adult individuals in the water of the Randers Fjord at a mean salinity of 7 to 10 $^0/_{00}$. Nor does the inner Fjord want in a substratum for the attachment of the mussel.

Another possibility is that a constant seaward current in the narrow part of the Fjord between the Jars peninsula and Svinø might directly obstruct the immigration, but this does not agree with the fact that during and after westerly gales bushes of *Fucus* full of *Mytilus* are found to be drifting as far inwards as about bottom sampler station 15. So these animals must suffer a rapid death if they are not carried to the outer Fjord once more.

It would seem more probable that the existence of the mussel depends on a constant inflow of seawater which takes place only near the Hestevaad and the Dybsø Strøm.

Only the specimens of the bottom samples were measured; they were all comparatively small and thin-shelled. The largest specimens (27.8, 26, and 25.5 mm.) were taken at bottom sampler station 24.

Of the total weight quantity taken with the bottom sampler and calculated per 1 sq. m. *Mytilus* constitutes 4.21 $^0/_0$; in the total weight quantity of the hand net samples, calculated per 1 sq. m. as well, it makes up 9.87 $^0/_0$.

2. *Cardium exiguum* Gmelin.

This bivalve occurs all over the Fjord with the exception of the freshwater outfalls, bottom sampler station 18, the water of which is polluted by sewage and thrown-out, rotten fish, and the bottom sampler stations 22, 23, 26, 30, 31, and 33 being deficient in vegetation. The vegetation of station 27 does not differ very much from that of the other bottom sampler stations where *Cardium exiguum* was found, but the depth of water is but 15 cms., the bottom material black detritus.

In spite of a rich vegetation of *Chara* at this locality *Cardium exiguum* does not appear in the hand net samples from station VI. It reaches its highest frequency in the western part of the Fjord (hand net stations XIII, XIV, and XV) and at station XI in the inner part of the Fjord.

This great difference between abundance (3156 mgs.

per 1 sq. m.) at hand net station XIV and total absence at bottom sampler stations 22 and 23 must be put down to a difference of vegetation: at hand net station XIV there is a rich vegetation of *Zostera* and *Fucus*, the two bottom samples stations, however, being situated in a completely barren patch of sand.

In the Ringkøbing Fjord this species has been found only in the form of fossils (Johansen 1914). Into the Randers Fjord it advances no farther than Odpolden (mean salinity 18 ‰).

Cardium exiguum occurs in the Kattegat S. E. of Læsø, in the Nyborg Fjord, Great Belt, Svendborg Sund, the Sound, Smaalandshavet, Storstrømmen, the Holbæk Fjord, and the eastern part of the Karrebæksminde Bay (Svinø Bay), nowhere, however, at depths of more than 14 m., and always in close connexion with the vegetation (Petersen 1913).

Of the total weight quantity of the bottom samples this species constitutes 1.62 %, of that of the hand net samples 4.51 %.

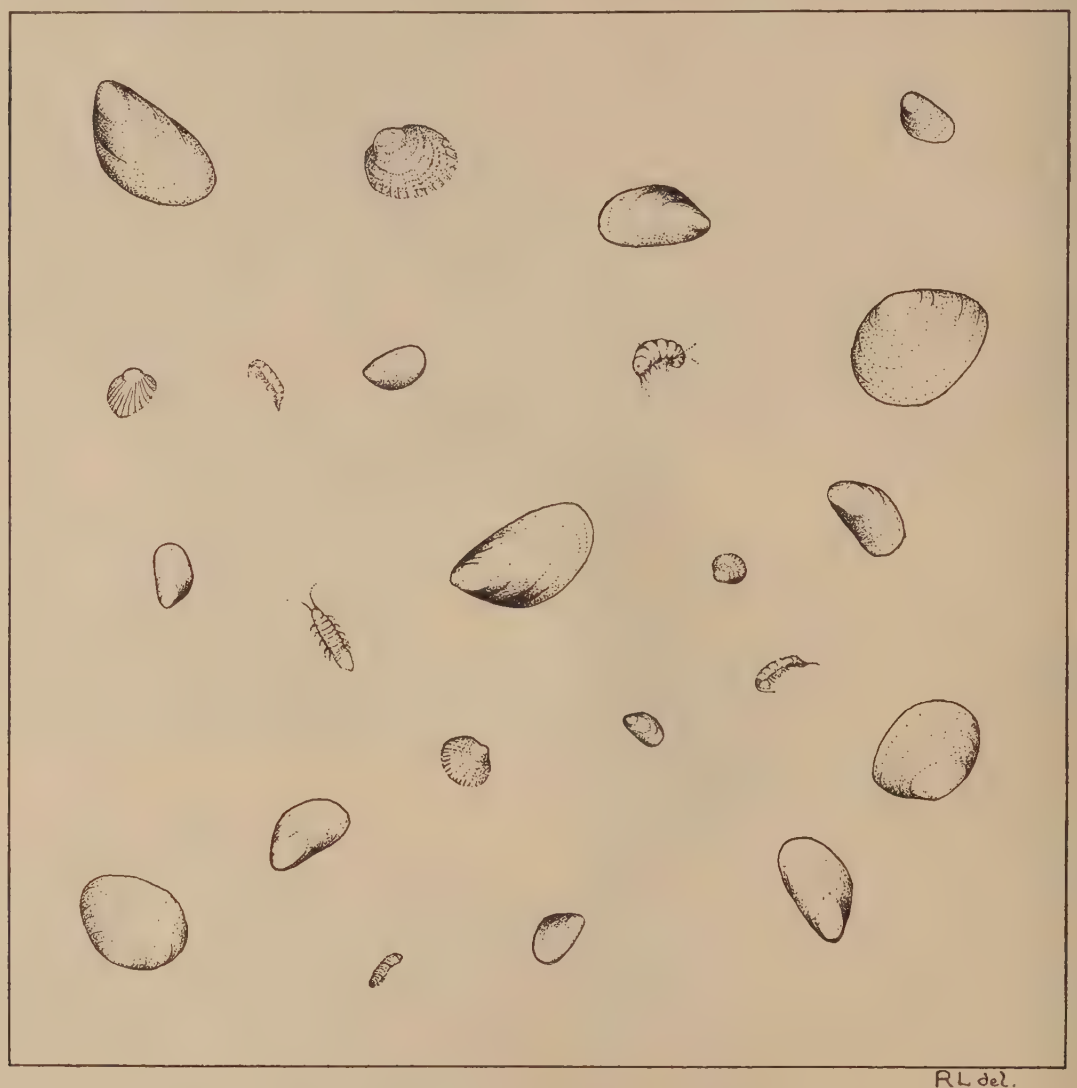

Figure 5. Species and numbers of the bottom animals in $^1/_{44}$ sq. m. at bottom sampler station 24. (*Mytilus edulis:* 11, *Cardium exiguum:* 1, *Cardium edule:* 3, *Macoma baltica:* 3, *Gammarus locusta:* 1, *Aoridae:* 2, *Idothea viridis:* 1, *Haemonia mutica:* 1). Natural size.

3. *Cardium edule* L.

Next to *Macoma baltica Cardium edule* is the most common bivalve of the Fjord. It has been noted to occur at all bottom sampler stations except No.s 2, 3, 8, and 12, and is even found at station 18.

Figure 6. Species and numbers of the bottom animals in $^1/_{44}$ sq. m. at bottom sampler station 30. (*Cardium edule:* 12, *Nereis diversicolor:* 1). Natural size.

It predominates at bottom sampler station 30 where more than 500 individuals occurred per 1 sq. m. (Figure 6). All individuals belong to the Fjord form, *forma baltica.*

This bivalve takes up an intermediate position between the in-fauna and the on-fauna. The older groups have dug themselves into the bottom; the younger groups (0-, I-, and II-Groups) are attached to the lower parts of the vegetation and thus constitute an easy diet of the fish wanting to feed on them. This goes well with the fact that these groups are most frequent in the fish stomachs. That they are extensively preyed upon appears from the fact that all other groups (individuals of more than 7 mm.) constituted but 48 % of the total number of individuals at the time when the bottom samples were taken.

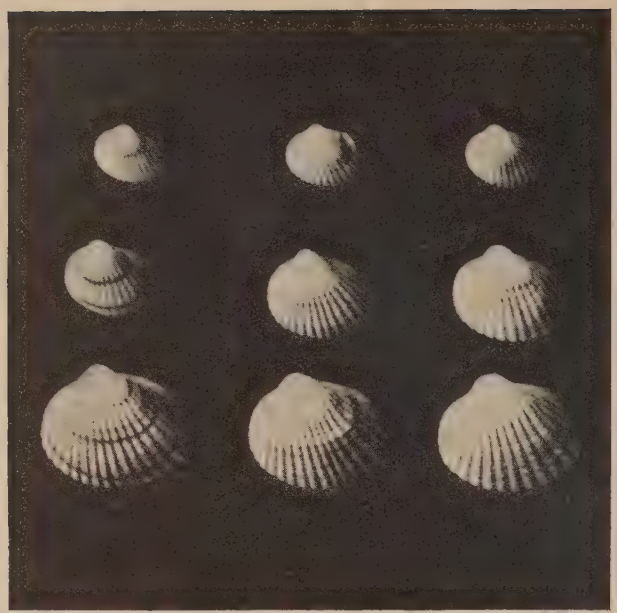

Figure 7. The three youngest groups of *Cardium edule* from sandy bottom (bottom sampler station 30). Top series I-Group, middle series II-Group, bottom series III-Group. On the animals of the left column the outer edge of the winter zones have been drawn in pencil. × 2½. (Aut. phot.).

The growth of *Cardium* in the Fjord is very slow, being somewhat quicker on the sandy bottom of the outer part than on the mixed bottom of the inner part. The lengths of the individuals at the ends of the growth periods were measured by the winter zones of the I-, II-, and III-Groups. In June the 0-Group had not yet reached the bottom stage. At this time the spatfall had no doubt taken place, the gonads of about one score of adult individuals being small and apparently spent[1]).

The below tables show the numbers of individuals of different lengths within the three groups on the end of the growth periods. Columns 1', 2', and 3' give the number of individuals of the length in question at the end of respectively the first, second, and third growth period (summer + winter); column A shows the distribution about the middle of June 1934. All lengths were measured to the nearest mm. above.

It will be noticed that on sandy bottom we find a maximum of individuals at 4 mm. on the end of the first growth period, at 5 to 6 mm. on the end of the second growth period, and at 7 mm. on the

[1]) This examination was carried out by Mag. scient. G. Thorson.

I. Sandy bottom. Bottom sampler stations 20, 24 and 30.

Numbers of individuals of the lengths in question.

	Groups measured								
	I		II			III			
Length in mm.	1'	A	1'	2'	A	1'	2'	3'	A
3	4	..	11	..	..	4	..	..	..
4	6	4	36	3	..	21	1	..	..
5	..	5	21	28	9	2	15	2	..
6	..	1	..	32	30	..	11	3	3
7	..	..	..	5	23	..	..	14	4
8	..	..	..	..	6	..	..	8	12
9	..	..	..	..	..	..	..	..	8
Totals examined	10		68			27			

II. Mixed bottom. Bottom sampler stations 7, 9, 10 and 14.

Numbers of individuals of the lengths in question.

	Groups measured								
	I		II			III			
Length in mm.	1'	A	1'	2'	A	1'	2'	3'	A
3	8	8	8	1	..	6	..	..	..
4	..	..	4	6	2	4	5	..	..
5	..	..	..	4	7	..	5	4	..
6	..	..	..	1	3	..	..	5	5
7	..	..	..	..	..	..	..	1	4
8	..	..	..	..	..	..	..	..	1
Totals examined	8		12			10			

end of the third growth period. The average lengths at the end of the three periods are found to be respectively 4.0, 5.5, and 7.0 mm. (cp. Figure 7). On the mixed bottom of the inner Fjord the average lengths are 2.3, 4.5, and 5.7 mm., respectively.

A comparison of these figures with those found by Orton (1926—27) for *Cardium edule* f. *regularis* (20.5, 29.5, 34.5, and 37.0 mm., respectively, for the 0-, I-, II-, and III-Groups) will convey to the reader a distinct impression of the degree to which the growth of salt water organisms is hampered by the influence of brackish water.

Cardium edule is present in 13 of the 17 hand net samples taken, the highest numbers occurring at station XIV, a locality altogether exhibiting a rich animal life. In most cases the individuals belong to the I- and II-Groups; the additional presence of older year-classes (as for instance at hand net station V) means that the hand net sample contains some bottom material.

This species is common throughout the Danish waters: it is reported to occur in such localities as the Ringkøbing Fjord (excluding the brackish water

period), the Roskilde Fjord (Blegvad 1925), and the Randers Fjord, in which place *forma baltica* is replaced by *forma inflata* in the inner and *forma regularis* in the outer Fjord. *Forma inflata* is found as far upwards as Støvring Sønderskov in water showing a mean salinity of 5 to 7 $^0/_{00}$. In the Baltic *forma baltica* advances into the Gulf of Bothnia.

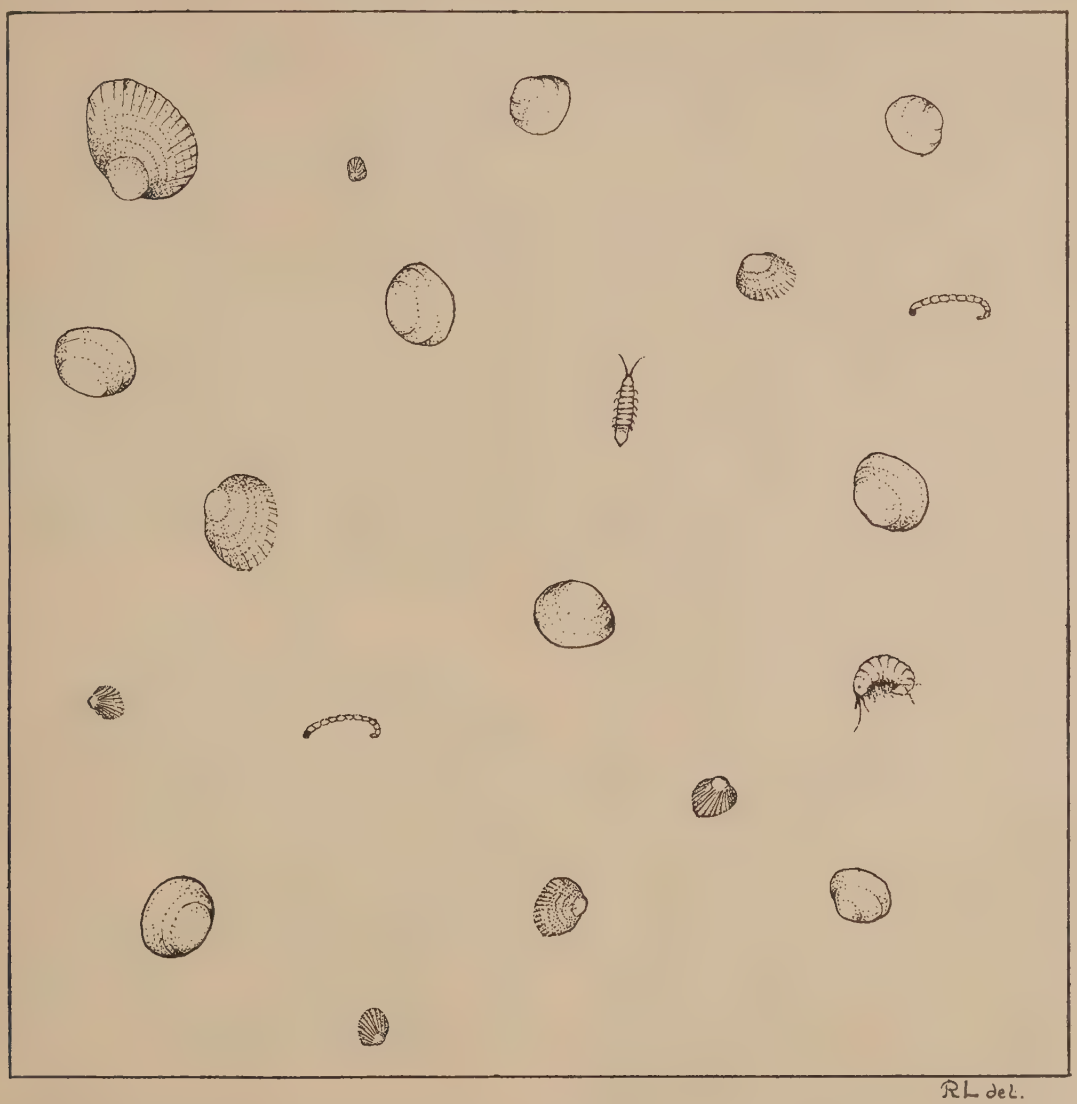

Figure 8. Species and numbers of the bottom animals in $^1/_{44}$ sq. m. at bottom sampler station 11. (*Cardium exiguum:* 4, *Cardium edule:* 4, *Macoma baltica:* 8, *Gammarus locusta:* 1, *Idothea viridis:* 1, *Chironomida larvae:* 2). Natural size.

4. *Macoma baltica* (L.).

The distribution of *Macomd baltica* in Danish waters is dealt with in the investigations of C. G. Joh. Petersen (1913).

In the Dybsø Fjord it was found at all bottom sampler stations with the exception of the freshwater outfalls and station 18. Its highest frequency is reached on the soft bottom of the stations of the inner Fjord round the mouth of Kyllebækken (Figure 8). No doubt the abundance of these localities is caused by the quantities of nourishment carried into the Fjord by this brook and formerly by Vejlegrøften. On "Vaderne" at Skalling Thamdrup (1935) observed similar conditions, the species attaining its highest frequency on localities abunding in food.

A salient feature, however, is the comparatively small size reached by the individuals of these crowded stations. Everywhere the average length ranges between 9 and 10.5 mm., and specimens of more than 13 mm. were not met with at all in the inner Fjord.

As to the cause of this fact it seems quite probable that the freshwater of Kyllebækken and formerly that of Vejlegrøften when carried into the Fjord may have caused a poor growth in the individuals exposed to the direct effects of the freshwater, that is to say the individuals of the inner Fjord. On the other hand it is just possible that these animals originate from an extraordinarily rich local spatfall, occurring now and then with these species, no one the wiser as to its causes. Such a fact might easily be traced by the winter zones if the shells of all individuals of the inner Fjord had not unfortunately become more decomposed than those of the individuals of the outer Fjord.

Only the bottom sampler station 23 showed so numerous a representation of the younger groups, that an age-determination by the winter zones and a classification of age-groups might be carried out. No 0-Group was found at the time of sampling (15-VI-34). The distribution of the various lengths within the I- and II-Groups in the month of June appears from the survey below:

Numbers of individuals of the length in question.

Length in mm.	I-Group	II-Group
5	1	..
6	..	..
7	3	..
8	9	..
9	7	2
10	4	2
11	..	5
Total examined	24	9
Average length	8,4	10,3

The largest specimen taken in the Fjord (20.2 mm.) originates from bottom sampler station 24.

In the total weight quantity of the bottom samples *Macoma baltica* constitutes 56.32 %, of the hand net samples 1.05 %. The occurrence of *Macoma* in the hand net samples is due to the same facts as were mentioned in dealing with the older groups of *Cardium*.

5. *Mya arenaria* L.

As far as this species is concerned the bottom sampler failed. Some small specimens (9.1—19 mm.) were taken at some few stations, mostly round the Jars peninsula and at bottom sampler station 32. That the individuals are more numerous than shown by the bottom samples and their lengths considerably greater appears from the fact that fresh shells of 30 to 40 mm. in length are often found to lie near the shore.

Unfortunately this means that the figures of the third column in Table 1, stating in per cent. the proportion between the weight quantities of the different species of the bottom of the Fjord, are lower for *Mya* and higher for the rest of the species than is really the case, which again will influence the figures of Table 2. A similar drawback arises through the bottom sampler not being able to dig out the *Arenicola* and (possibly) through the hand net failing to bring out *Leander* and *Crangon*.

Thus, if we put the percentage weight quantity of *Mya* in the bottom samples at 2.31, this figure must be used with all reserve.

B. Gasteropods.

The bottom samples being taken principally in places of the thinnest vegetation, I have left out all gasteropods brought out by the bottom sampler, with the exception of *Limnaea ovata*, so that the material of *Hydrobia*, *Rissoa*, *Littorina*, and *Neritina* originates exclusively from the quantitative hand net samples.

The biology of the gasteropods was examined by Mag. scient. G. Thorson by means of material from those samples mentioned in the introduction that were taken in fine-meshed dredge (during the period of June 5th to 19th, 1934).

1. *Hydrobia ulvae* Pennant.

Hydrobia occurs at all hand net stations, reaching its highest frequency in the outer Fjord (hand net stations VII, XIV, and XV).

All individuals examined belong to the still nameless form that has no pelagic larvae. The whole development takes place in the egg, from which the animal enters the bottom stage directly. This fact seems to be characteristic of the Hydrobiae of brackish water.

In the material are found some egg capsules although the spawning of this species cannot be said to be culminating.

Of the total weight quantity of the hand net samples *Hydrobia* constitutes 23.16 %.

2. *Rissoa* sp.

This annual gasteropod, the occurrence of which is subject to very great fluctuations (Petersen 1918), was found in considerable quantities at three hand net stations only: VIII, XIV, and XV. With the exception of hand net station II it is also reported to occur at the other hand net stations, but only in small numbers. The individuals found all belong to the generation of the previous year; at any rate small specimens were not met with.

In the material from June, 1934, *Rissoa inconspicua* Alder was found to be absolutely in the majority, *R. violacea* Desmarest occurring in comparatively small numbers.

Numerous egg capsules of *Rissoa* were found, and the spatfall must be said to have been very near its culmination.

Rissoa made up 7.66 % of the total weight of the hand net samples.

3. *Littorina rudis* Maton.

Of *Littorina rudis* only *forma tenebrosa* is found in the Fjord. It is equally frequent in the inner and the outer Fjord, only with a maximum at hand net station XIV. The individuals of the western part of the Fjord come very close to the typical form, those of the inner Fjord being always small and black. According to Johansen (1918) the species requires a mean salinity of 14 ‰ to develop into its typical form.

This species constitutes 25.27 % of the total weight quantity of the hand net samples.

4. *Neritina fluviatilis* L.

All individuals found in the Fjord belong to the brackish water form, *forma littoralis*, distinguished by its small size and bluish black colour. It is reported to occur at all hand net stations and is uniformly distributed in all places where the bottom is covered with vegetation.

In the Dybsø Fjord this species reaches its highest limit of salinity, being unknown in Danish waters with a salinity of more than 13 ‰ (Johansen 1918).

It makes up 2.49 % of the total weight quantity of the hand net samples.

5. *Limnaea ovata* L.

Limnaea ovata was taken with bottom sampler at station 4 and 5 and with hand net at stations IV, VII, and XVII. Its frequency culminates at hand net station IV (47 specimens in 2 samples of 1 sq. m. each).

Only the specimens of the bottom samples were measured; the maximum size is 9.6 mm. In the Randers Fjord the maximum size is 23.1 mm. in freshwater, 12.1 mm. in water of a salinity of 6 ‰. In this Fjord the species is not found at higher mean salinities, but it occurs in the Sound and Smaalandshavet at salinities of 10 to 11 ‰. The size seems to decrease by an increasing salinity.

Of the total weight quantities of bottom samples and hand net samples *Limnaea ovata* constitutes 0.06 % and 1.51 %, respectively. The latter figure is sure to be the more correct.

C. Crustaceans.

1. *Gammarus locusta* L.

This most common amphipod of the littoral regions of our waters is distributed all over the Fjord, one specimen even occurring at bottom sampler stations 8 and 18. The highest frequency is reached at hand net station XIV (52 specimens per 1 sq. m. with a weight of 2065 mgs.). At the other stations the numbers are so few, that any great economical importance of this species would seem to be out of the question. But if we consider the annual production (Blegvad 1921), we see that it constitutes no small part of the easily accessible favourite food of cod and flounder.

All individuals taken in the Fjord belong to the *forma typica*.

The species constitutes 0.22 and 1.31 % of respectively bottom samples and hand net samples.

2. *Melita palmata* (Mont.).

A few specimens taken both in the inner and the outer Fjord. Only the specimens of the bottom samples were determined as to species. In the hand

net samples it was put down as *Aoridae* together with *Microdeutopus gryllotalpa* Costa.

The species is reported to be infrequent in the Sound where it prefers the soft-bottomed parts of the littoral region, but is said to be more frequent in the Baltic (Björck 1915). In the Randers and Ringkøbing Fjords the species is unknown.

Of the total weight quantity of the bottom samples it constitutes 0.05 %. Together with *Microdeutopus gryllotalpa* it makes up 0.22 % of the total weight quantity of the hand net samples.

3. *Microdeutopus gryllotalpa* Costa.

Shows nearly the same distribution in the Fjord as *Melita palmata.*

It was taken in the Randers Fjord near Udbyhøj but not in the Ringkøbing Fjord. Björck states it to be common in the shallow waters of the Sound.

It constitutes 0.03 % of the total weight amount of the bottom samples.

4. *Corophium volutator* Pallas.

Corophium volutator is one of the most euryhaline crustaceans of the Danish fjord fauna. In the Randers Fjord it was taken in water the mean salinity of which ranges between 2 and 17 ‰, in the Ringkøbing Fjord everywhere, the thinnest population occurring in Strømmen.

In the Dybsø Fjord its frequency culminates at the stations near the freshwater outfalls (Figure 9), the bottom sampler station 12 showing an amount of more than 1300 specimens per 1 sq. m. Undoubtedly, this is not caused directly by the freshwater, but is probably due to the quantities of organic matter carried into the Fjord by the streamlets. Furthermore this water is nearly free from the competitor of *Corophium*, *Cardium edule*, a fact which is considered very important by Thamdrup (1935). That its abundance is not due to the small depths of these stations appears from the fact that *Corophium* was not taken at the bottom sampler stations 26, 29, 31, and 32 where the depths do not exceed 0.5 m.

This species makes up 1.71 % of the total weight amount of the bottom samples. As might be expected from its way of living it does not occur in the hand net samples.

5. *Sphaeroma rugicauda* Leach.

Only taken at bottom sampler stations 8 and 12 in the mouths of Kyllebækken and Vejlegrøften in quite shallow water.

The species has been found in the Randers Fjord, but strange to say only in the outer part of it (salinity 5 to 20 ‰). Meinert (1890) reports that it able to live in nearly fresh water. The present author found it in the mouth of the Skive Aa in the summer of 1934.

It constitutes 0.02 % of the total weight amount of the bottom samples but was not found in the hand net samples.

6. *Idothea viridis* (Slabber).

Idothea viridis is the most common isopod of the Fjord. In the bottom samples it is only lacking from stations 2, 12, and 23. At stations 2 the water is no doubt too fresh, to station 12 it has hardly immigrated as yet after the barring of the ditch, and station 23 has no vegetation. It is found in all hand net samples, maxima occurring at stations XIV and XV.

Judging by the numerous stock found in the Fjord in spite of the large amount consumed, the breeding habits of *Idothea* are scarcely different from those of *Gammarus locusta.* A detailed investigation of this question would be most desirable.

Contrary to expectation the other *Idothea* species, *Idothea baltica* Pallas, was not found in the Fjord. Only in one case an individual aroused some doubt as regards species, the shape of the telson reminding of that of *I. baltica.* Other proportions, however, as for instance length and breadth, the breadth of the head as compared with that of the body, etc., distrinctly proved it to be an *I. viridis.*

Regarding the distribution of the two species in other waters it may be mentioned that in the Randers Fjord *I. baltica* is not found at lower salinities than 10 to 12 ‰ while *I. viridis* advances a long way farther into the Fjord. In the Ringkøbing Fjord *I. baltica* was taken only in Nymindestrømmen whereas *I. viridis* is known to occur both in Strømmen and other parts of the Fjord. In the Baltic *I. baltica* advances to the Gulf of Bothnia. On account of a confusion of the species *I. viridis* and *I. granulosa* Rathke we do not know the exact distribution of the former in the Baltic (Björck 1915). We know for certain, however, that all three species have been taken at the south of Finland (Wahrberg 1930).

Of the total weight amount of the bottom samples *Idothea* makes up 0.51 %, of the hand net samples 4.33 %.

Figure 9. Species and numbers of the bottom animals in $^1/_{44}$ sq. m. at bottom sampler station 8. (*Corophium volutator:* 8, *Idothea viridis:* 1, *Nereis diversicolor:* 11, *Oligochaeta:* 1, *Chironomida larvae:* 5). Natural size.

7. *Iaera marina* (Fabr.).

In the bottom samples only found at station 17, in the hand net samples at stations V, X, XI, XIV, and XV; at the two last-mentioned stations the highest frequency is reached with respectively 7 and 3 individuals per 1 sq. m.

In the total weight amount of the bottom samples the percentage of *Iaera* is quite insignificant; of the hand net samples it constitutes 0.01 %.

8. *Cyathura carinata* Krøyer.

This species is known only from the bottom samples. It was taken in the inner Fjord and at the stations south and west of the Jars peninsula. In the outer part of the Fjord it is unknown.

It constitutes 0.06 % of the total weight of the bottom samples.

9. *Mysis vulgaris* Thompson.

10. *Mysis flexuosa* O. Fr. Müller.

Only one specimen of *Mysis vulgaris* is known with certainty to have been taken in the Fjord, at bottom sampler station 22. The hand net material of *Mysids* was not determined as to species, but a large material from samplings with a fine-meshed dredge turned out to contain nothing but *Mysis*

flexuosa. So this fact is quite contrary to the conditions of the Randers and Ringkøbing Fjords: here *Mysis vulgaris* predomites, the occurrence of *Mysis flexuosa* being confined to the mouths of the Fjords.

Of the total weight amount of the bottom samples the two species collectively make up 0.01 %, of the hand net samples 0.70 %.

Possibly the quantitative hand net was not the very best gear for the purpose of catching these swiftly moving animals. So the figures should be used with reserve, a condition applying to the two following species as well.

11. *Leander adspersus* (Rathke).

Leander adspersus is extremely common in the Fjord and the object of a profitable weal fishery. It was taken in the bottom sample of station 10 and in all hand net samples except the one taken at station V. It seems to reach its highest frequency in the western part of the Fjord, but it is doubtful whether this is really the case or the results of samplings rest on coincident conditions.

Of the total weight of the hand net samples it constitutes 5.91 %, but this figure is undoubtedly somewhat low, which is also the case with the figure of its percentage occurrence in the bottom samples, 0.06 %.

12. *Crangon vulgaris* Fabr.

Crangon vulgaris is extremely common in the Fjord but difficult to catch with the gear at disposal for the investigation. It was observed to be numerous on the bottom of both the inner and the outer Fjord and is caught in quantities in the shrimp weals along the shore and in the Hestevaad.

It makes up 1.62 % of the total weight of the hand net samples. It does not appear in the bottom samples.

D. Vermes.

1. *Nereis diversicolor* Müll.

In its distribution in the Fjord *Nereis diversicolor* chooses fairly the same localities as *Corophium* with maxima at the stations in the freshwater outfalls (Figure 9) and in the Hestevaad. Further a few specimens were taken at some other stations all over the Fjord. The causes of these large quantities living at the stations of the outfalls are undoubtedly the same as were discussed in the case of *Corophium*.

Furthermore, *Nereis* was caught at some hand net stations where it lives in the accumulations of mud gradually gathering in the dense vegetation.

Of the total weight amount of the bottom samples the species makes up 4.52 %, of that of the hand net samples 0.23 %.

2. *Arenicola marina* L.

It was already mentioned that the bottom sampler could not make its way into the bottom deep enough for bringing out a satisfactory material of *Arenicola marina*, more particularly not because this polychaete often lives in hard bottom. So it is impossible, on the basis of the bottom samples alone, to picture the distribution of *Arenicola* in the Fjord, and unfortunately I got no time for counting the heaps of excrement. However, these heaps were observed everywhere in the Fjord where the bottom was suitable for *Arenicola*: they were perhaps largest and most numerous in the western part of the Fjord.

Consequently, 0.72 % is far too small a figure to represent the percentage weight quantity of *Arenicola* in the bottom samples.

3. *Oligochaeta.*

At a few bottom sampler stations, particularly at the freshwater outfalls (Figure 9), were taken some small *Oligochaetes*, but unfortunately it was impossible to determine the species.

They made up 0.01 % of the total weight amount of the bottom samples.

4. *Rhynchocoela.*

Nemertines were taken both in the inner and the outer Fjord, but the species could not be ascertained. The colour is greyish green. The animals are present both in bottom and hand net samples, in the total weight amount of which they constitute 1.14 and 0.29 %, respectively.

5. *Turbellaria.*

Some few *Turbellaria* were taken at hand net stations XI, XII, and XIV. Species not determined.

They constitute 0.03 % of the total weight amount of the hand net samples.

E. Insects.

1. *Orthetrum cancellatum* L.

The larvae of this species were taken at the two shallow bottom sampler stations 21 and 27. In brackish waters of this country it has been taken only once before now, viz. in the Stadil Fjord in 1911 (salinity 14.42 ‰). Besides in the bottom samples the species was observed in the boats' harbour of Basnæs (21-V-35).

It constitutes 0.16 % of the total weight of the bottom samples. It does not occur in the hand net samples.

2. *Ischnura elegans* v. d. Lind.

One larva was taken at bottom sampler station 21. Common in brackish water. It is found on the southern and eastern shores of the Ringkøbing Fjord (Henriksen 1934) and in the Randers Fjord where it was taken in numbers in water of a mean salinity of 10.63 ‰ (Ussing 1918).

3. *Oecetis ochracea* Curt.

A few larvae of *Oecetis ochracea* were taken both in bottom sampler and hand net in the inner and the eastern part of the outer Fjord. The species is common in brackish water.

It constitutes 0.03 % of the total weight amount of the bottom samples; in the hand net samples its weight is so insignificant (4 mgs. in total) as to be quite negligible.

4. *Haemonia mutica* Fabr.

Larvae of *Haemonia mutica* were taken in small numbers at bottom sampler stations 5, 24, 26, and 27 and at hand net station XIV. It is distinctly a habitant of the vegetation, and its whole existence depends on the presence of oxygen-producing plants.

In the Randers Fjord the genus is known from station IX (Ussing 1918).

The species constitutes 0.07 % of the total weight amount of the bottom samples, 0.01 % of that of the hand net samples.

5. *Haliplus obliquus* F.

3 specimens occurred in 2 samples of 1 sq. m. apiece at hand net station XII.

As far as known this species was not formerly found in the sea. In Germany, however, it was found in inland salt waters at Mansfeld and Stassfurt (Schaum 1843).

Its percentage weight in the hand net samples is only about 0.0025 %, and so this small figure will be ignored in the following.

6. *Chironomidae.*

Larvae of *Chironomidae* were met with everywhere in the Fjord except at bottom sampler station 6, which is no doubt a mere accident. The numbers of larvae, however, were highly varying (from 4 to more than 8 000 per 1 sq. m.), but the cause of this fact could not possibly be established.

Also in the hand net samples this group is present, some larvae showing the same habits as the *Nereis diversicolor* of the hand net samples. The larvae from hand net station XII are 10 to 15 mm. long, of an intense red colour, and have one pair of blood gills.

Of the total weight amount of the bottom samples the *Chironomids* constitute 2.00 %, of that of the hand net samples 0.23 %.

F. Vertebrates.

Besides the Invertebrates described some few fishes occurred in the hand net samples: *Gobius niger* L., *Gobius minutus* Pallas, *Gasterosteus aculeatus* L., and *Gasterosteus pungitius* L.

These fish, however, are so good swimmers, that the material brought out by the hand net is not by far representative of the stock of the locality. So these animals have been mentioned only to complete the description, and their respective percentages of the total weight amount of the hand net samples (1.85, 0.19, 0.27, and 1.93 %) cannot be used for a calculation at all.

For the purpose of getting a general impression of the proportion between the occurrence of the different invertebrates in the Fjord it is necessary, however, to know not only their percentage occurrence in the two series of samples, but also their average percentage occurrence per 1 sq. m. These figures are found in Table 1 (3rd column).

The average weight amount per 1 sq. m. of all animals was calculated in three ways. For the

Table 1.

Species	mgms. per 1 sq.m.	Calculated by	Weight percentage of the individual species in the total quantity of animals per 1 sq.m.	Percentage occurrence of the species in the fish stomachs						
				Eel	Flounder	Cod	Sea scorpion	Viviparous blenny	Black goby	Roach
Mytilus edulis	3 529	A + B	5.21	..	×	..	..	..	..	×
Cardium exiguum	1 441	A + B	2.13	0.06	20.08	..	..	0.67	..	×
Cardium edule	14 325	A + B	21.16	..	20.58	..	..	..	..	..
Macoma baltica	32 064	A	47.35	..	6.26	..	..	..	..	..
Mya arenaria	1 348	A	1.99	..	..	..	..	..	..	..
Hydrobia ulvae	2 659	B	3.93	0.04	0.40	0.05	..	5.61	..	×
Rissoa sp.	880	B	1.30	..	0.15	0.06	0.02	0.57	..	..
Littorina rudis	2 901	B	4.28	0.01	0.06	0.06	0.11	1.31	..	×
Neritina fluviatilis	286	B	0.42	0.17	..	..	0.05	..	..	×
Limnaea ovata	173	B	0.26	2.88	..	..	..	..	..	×
Gammarus locusta	275	A + B	0.41	4.11	3.14	5.86	1.90	0.51	21.28	..
Aoridae	69	A + B	0.10	0.02	..	..	..	..	0.44	..
Corophium volutator	972	A	1.44	..	0.08	..	..	..	..	..
Sphaeroma rugicauda	..	..	..	..	..	..	..	..	..	..
Idothea viridis	789	A + B	1.17	18.23	41.06	7.82	3.07	25.93	10.37	..
Iaera marina	..	..	..	..	..	..	..	..	..	..
Cyathura carinata	36	A	0.05	0.05	..	..	0.02	..	..	..
Mysis sp.	81	B	0.12	..	0.10	..	0.08	..	9.84	..
Leander adspersus	679	B	1.00	23.55	0.78	20.37	51.53	57.50	58.07	..
Crangon vulgaris	186	B	0.27	5.91	1.36	31.07	13.97	..	..	..
Nereis diversicolor	2 601	A + B	3.84	..	..	..	..	..	..	..
Arenicola marina	412	A	0.61	13.57	..	..	..	..	..	..
Oligochaeta	7	A	0.01	..	..	..	..	..	..	..
Rhynchocoela	686	A + B	1.01	..	..	..	..	..	..	..
Turbellaria	4	B	0.01	..	..	..	..	..	..	..
Orthetrum cancellatum	92	A	0.14	..	..	..	0.61	..	..	..
Ischnura elegans	..	..	..	..	..	..	..	..	..	..
Oecetis ochracea	17	A	0.03	0.03	..	..	..	..	..	..
Haemonia mutica	41	A + B	0.06	..	..	..	..	..	..	..
Haliplus obliquus	..	..	..	..	..	..	..	..	..	..
Chironomidae	1 156	A + B	1.70	0.03	5.97	..	0.04	..	..	..
Gobius niger	..	..	..	2.39	..	..	23.29	..	..	..
Gobius minutus	..	..	..	..	..	7.05	..	..	..	..
Gasterosteus aculeatus	..	..	..	2.74	..	24.26	2.60	..	..	..
Gasterosteus pungitius	..	..	..	2.77	..	3.38	2.72	7.90	..	..
Eggs of *Gasterosteus* sp.	..	..	..	23.44	..	..	..	..	..	..

animals appearing only in the bottom samples, or the occurring of which in the hand net samples seems to be merely accidental, the total weight of the species in the bottom samples, after the latter had been calculated per 1 sq. m. for each separate station, was divided by the number of samples (A). For the animals occurring in the hand net samples and not, or only accidentally, in the bottom samples the average figure was calculated only by the quantity in the hand net samples of the species in question (B). For animals occurring with an equal right in bottom samples and hand net samples the average figures of the two sampling series were added (A + B).

For the minor gasteropods the figures are a little low because the individuals of the bottom samples were not included. But the error is hardly very great.

It is interesting to note the preponderance of the mollusks, which make up about 88 % of the average weight per 1 sq. m. of all animals. The remaining 12 % are taken up by crustaceans, worms, and insects with about 4.5, 5.5, and 2.0 %, respectively. Of the last group the *Chironomids* alone constitute 1.7 %.

The errors arising on account of the insufficiency of technique were already discussed (p. 16).

The average weight amount of all animals per 1 sq. m. is about 67 gms., and none of the animals brought out are so large as to be unfit for fish food (cp. Blegvad 1925).

IV. Nutrition and Growth of the Fish.

The following states the results of the stomach investigations of the fish of the Fjord. As already mentioned the fish were caught partly in weals and "Toggergarn", partly on hooks or by torchlight. Weals and "Toggergarn" were used only during the period of April, 14th—23rd, hooks from June, 3rd—9th 1935. On June, 4th, 5 eels were taken by torchlight.

Of the eels 16 specimens were taken in weals, 72 on hooks, and 5 by torchlight. In view of avoiding a heterogeneity of the material only the eels taken during the latter period (June, 3rd—9th) were used for the determination of age.

Of the flunders 2 were caught in "Toggergarn", 55 in weals, and 4 on hooks. Only the material dating from the former period (April, 14th—23rd) was used for the age determination.

All the cods were caught in weals, and so were the viviparous blennies and the gobies.

22 sea scorpions were taken in "Toggergarn", 11 in weals.

27 roaches were taken in "Toggergarn", 14 in weals.

Immediately after the capture the fish were killed and measured and the stomach contents taken out. The elements of the composition were sorted, water and adherent viscid matter removed by means of filter-paper, and then the measurings were carried to an exactitude of 1 mg.

For each species will be discussed the method used for the age determination.

The growth of the fish was examined because it will yield a rough impression of the quality of the food.

1. Eel (*Anguilla vulgaris* Turton).

A total of 93 eels were examined, 69 of which had stomach contents. The percentage composition of the latter appears from Table 1 (4th column).

It is seen by the table that the principal food of the eel is crustaceans, and among them *Leander adspersus* and *Idothea viridis* are preferred. The richness of the Fjord in mollusks, however, is badly utilized; only the gasteropods of the epifauna and *Cardium exiguum* being taken by the eel.

The apparently small representation of *Corophium volutator* and the *Chironomids* in the eel stomachs may be due to the comparatively small material of fish examined.

Corophium is often reported (i. a. Poulsen 1934) to play a great part in the food of flounder and eel, which is an obvious supposition when you consider the distribution and habits of this animal. In dealing with the importance of *Corophium* as fish food Stephensen and Ussing (1918) can only mean that the consumers are flounder and eel. Judging by the material in hand, however, the importance of *Corophium* in the Dybsø Fjord is very small as regards the flounder, and to the eel it is nil.

If we examine pointed-headed eels from lakes, it is seen that *Chironomids* (especially of the genus *Chironomus*) often make up the bulk of the food. A similar state of things might be expected to appear in brackish water, but apparently this is not the case. No doubt it is the easily accessible crustaceous food that makes the eel ignore the *Chironomids* as a food matter.

Eggs of stickleback constitute 23.44 % of the total food amount. It is a well-known fact that the eel devours the spawn of other fish and is often taken with "roe in it", which by unstudied people is often taken as a proof against the fact of the remote breeding places of the eel.

The three fish species *Gobius niger*, *Gasterosteus aculeatus*, and *Gasterosteus pungitius* are nearly equally numerous in the eel stomachs, but *Gobius minutus* does not occur here.

A question unanswered by Table 1 is: in how many cases do the individual food animals occur in the eel stomachs? This appears from the below survey where the figures denote the number of eels with the said animal in their stomachs.

The survey shows us that *Idothea viridis* is the animal reaching the highest frequency in the eel stomachs. Next follow *Gammarus locusta* and *Leander adspersus*.

Arenicola marina, the percentage weight quantity of which is comparatively large, was found only in two eel stomachs with one specimen in each. These

Cardium exiguum	1	*Leander adspersus*	22
Hydrobia ulvae	6	*Crangon vulgaris*	6
Littorina rudis	1	*Arenicola marina*	2
Neritina fluviatilis	6	*Oecetis ochracea*	1
Limnaea ovata	10	*Chironomidae*	1
Gammarus locusta	24	*Gobius niger*	1
Aoridae	2	*Gasterosteus aculeatus*	1
Idothea viridis	57	*Gasterosteus pungitius*	3
Cyathura carinata	2	Eggs of *Gasterosteus* sp.	31

eels were the two longest specimens examined (52 cms.).

As to the proportion between the occurrence of the individual animal species in the Fjord and in the fish stomachs cp. Table 2.

The results of measurings and age determinations of 30 eels are stated in the below survey. For the age determination was used the method shown by Gemzøe (1907), who takes for his basis the number of winter zones in the scale.

Numbers of individuals of the lengths in question.

	III-Group		IV-Group		V-Group		VI-Group		VII-Group	
Length in cms.	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
27	1	..	..	..	..	..	..	..	..	..
28	..	..	..	..	..	..	..	..	..	..
29	..	..	..	..	..	..	..	..	..	..
30	..	..	..	..	..	..	..	..	..	..
31	..	..	..	..	..	..	..	..	..	..
32	..	..	..	1	..	..	..	..	..	..
33	..	..	..	..	..	..	..	..	..	..
34	..	..	..	..	..	..	..	..	..	..
35	..	..	..	3	..	..	..	..	..	..
36	..	..	2	1	..	..	..	..	..	..
37	..	..	..	..	..	1	..	..	..	..
38	..	..	..	..	..	3	..	..	..	..
39	..	..	1	1	..	..	..	..	..	..
40	..	..	..	..	2	..	..	..	..	..
41	..	..	..	..	..	..	..	1	..	..
42	..	..	1	..	..	..	1	..	..	..
43	..	..	..	..	..	..	..	..	..	..
44	..	..	..	..	..	..	2	..	..	..
45	..	..	..	..	1	..	..	..	..	..
46	..	..	..	..	..	..	..	..	3	..
47	..	..	..	..	..	..	..	..	..	..
48	..	..	..	..	..	..	3	..	..	..
49	..	..	..	..	..	..	..	..	..	..
50	..	..	..	..	..	..	..	..	..	..
51	..	..	..	..	..	..	..	..	..	..
52	..	..	..	..	..	..	2	..	..	..
Total number examined	1	..	4	6	3	4	8	1	3	..
Average length	27.0	..	38.2	35.2	41.5	37.8	47.3	41.0	46.0	..

Time of capture: June 3rd—9th, 1935.

A comparison of these figures with those found by Gemzøe (1907) for the Roskilde Fjord indicates that the males of the Dybsø Fjord would seem to grow a little faster than those of the Roskilde Fjord; in the case of the females there is no difference worth mentioning.

If, finally, we compare the figures with those found by Ehrenbaum (1930), it is seen that both in the Roskilde Fjord and the Dybsø Fjord the eel is growing faster than in freshwater. Furthermore, the winter zones of the eels of the Dybsø Fjord are much more distinct than in freshwater eels of the same age.

2. Flounder (*Pleuronectes flesus* L.).

A total of 61 specimens examined, 14 of which had stomach contents.

It is seen by Table 1 (5th column) that the flounder is a bivalve-crustacean-feeder. Of bivalves it prefers the easily accessible forms like *Cardium exiguum* and the 0-, I-, and II-Groups of *Cardium edule* while the buried forms like *Macoma baltica* are in the minority in the stomach contents, and *Mya arenaria* are lacking completely.

Mytilus edulis is generally reported to constitute the principal part or at any rate a large percentage of the food of the flounder (Petersen 1890, Otterstrøm 1914, Blegvad 1916). However this is not the case with the material of flounder dealt with here, but, on the other hand, this fact may be due to the small quantity of the material. Most of the flounders examined originate from the western part of the Fjord, the area where *Mytilus* occur in the largest numbers. Only in one case the fragment of a *Mytilus* shell was found in a flounder from the Hestevaad.

The utilization of small gasteropods seems to be a little better than in the case of the eel though it is not very intensive (cp. Blegvad 1916). An investigation during the maximum of *Rissoa* would no doubt show a better though not comparatively better utilization of this gasteropod.

Of crustaceans the flounder seems to prefer the slower forms like *Idothea*, the good swimmers, which keep above the bottom, showing the poorest representation. *Corophium* was found in the stomach contents in one case only, in an individual of the I-Group (7 cms.).

Worms were never found in the stomach contents.

However, the flounder seems to feed more extensively on *Chironomids* than does the eel.

Fish were not met with in the stomach contents.

The following survey shows how many times the individual food animals were found in the flounder stomachs.

Mytilus edulis	1	*Gammarus locusta*	8
Cardium exiguum	6	*Corophium volutator*	1
Cardium edule	6	*Idothea viridis*	12
Macoma baltica	2	*Mysis* sp.	1
Hydrobia ulvae	7	*Leander adspersus*	2
Rissoa sp.	2	*Crangon vulgaris*	1
Littorina rudis	4	*Chironomidae*	5

In other words: *Idothea* and *Gammarus* are in the majority also in the stomach contents of the flounder.

The age of the flounder was determined by the zones of the otoliths. The distribution of the age groups at the different lengths appears from the below survey.

Numbers of individuals of the lengths in question.

Length in cms.	I-Group	II-Group	III-Group	VI-Group	IX-Group
7	2	..	..	..	..
8	2	..	..	..	..
9	..	2	..	..	..
10	..	1	..	..	..
11	..	2	..	..	..
12	..	1	..	..	..
13	..	2	..	..	..
14	..	1	1	..	..
15	..	..	..	..	..
16	..	..	..	..	..
17	..	4	..	..	..
18	..	4	1	..	..
19	..	1	2	..	..
20	..	2	6	..	..
21	..	..	4	..	..
22	..	1	6	..	..
23	..	1	1	..	..
24	..	..	2	..	..
25	..	..	1	..	..
26	..	..	1	..	..
31	..	..	..	1	..
32	..	..	..	..	..
33	..	..	..	1	..
49	..	..	..	..	1
Total number examined	4	22	25	2	1
Average length	7.5	15.7	21.1	32.0	49.0

Time of capture: April, 14th—23rd, 1935.

3. Cod (*Gadus callarias* L.).

The cod is one of the less common fish of the Fjord: the material examined consists of only 16 individuals, 12 of which with stomach contents.

It is distinctly a crustacean-fish-feeder, in the food of which gasteropods constitute but a minute percentage.

Among the crustaceans it seems to prefer the large species, more particularly the benthic forms (*Crangon*).

Most of the fish occurring in the stomachs are *Gasterosteus aculeatus*.

Bivalves and worms were not found in the stomach contents, which in this case, too, should perhaps be put down to the small material.

It appears from the following survey in how many cases the different food animals were found in the cod stomachs.

Hydrobia ulvae	1	*Leander adspersus*	2
Rissoa sp.	1	*Crangon vulgaris*	9
Littorina rudis	1	*Gasterosteus aculeatus*	3
Gammarus locusta	4	*Gasterosteus pungitius*	1
Idothea viridis	6	*Gobius minutus*	1

The age of the cod was determined by the zones of the otoliths. The distribution of age groups at the different lengths is seen by the survey following below.

Numbers of individuals of the lengths in question.

Length in cms.	I-Group	II-Group
12	1	..
13	..	..
14	..	..
15	2	..
16	..	..
17	..	..
18	3	..
19	..	..
20	..	..
21	3	..
22	..	..
23	1	..
24	1	..
25	1	..
36	..	1
37	..	..
38	..	..
39	..	2
40	..	1
Total number examined	12	4
Average length	18.0	38.5

Time of capture: April 20th, 1935.

4. Sea scorpion (*Cottus scorpius* L.).

33 specimens examined, 21 of which with stomach contents.

Apparently the food of the sea scorpion is not very different from that of the cod; the chief difference appears in *Leander adspersus* and *Crangon vulgaris* having exchanged parts, so that the former is more extensively preyed upon. This fact adds another blemish to the bad character of this noxious animal, its noxiousness manifesting itself not only in its acting as a food competitor of the useful fish, but also in the fact that it preys upon an animal stock of the economic importance of *Leander*.

Small gasteropods are rarely taken by the sea scorpion whereas fish make up a considerable part of its food. *Gobius niger* preponderates in weight, but in a numerical respect *Gasterosteus pungitius* is the predominant fish of the stomach contents.

The numbers of cases in which the food animals appear in the stomach contents are the following:

Rissoa sp.	1	*Leander adspersus*	15
Littorina rudis	2	*Crangon vulgaris*	6
Neritina fluviatilis	1	*Orthetrum cancellatum*	1
Gammarus locusta	7	*Chironomidae*	1
Idothea viridis	7	*Gobius niger*	3
Cyathura carinata	1	*Gasterosteus aculeatus*	1
Mysis sp.	1	*Gasterosteus pungitius*	5

The age of the sea scorpions was determined by the number of zones of the otoliths. The distribution of age groups at the different lengths appears from the below survey.

Numbers of individuals of the lengths in question.

	II-Group		III-Group		IV-Group		V-Group	
Length in cms.	♀	♂	♀	♂	♀	♂	♀	♂
12	..	1	..	..	..	..	..	..
13	1	..	..	..	..	..	..	..
14	..	..	..	..	..	..	..	..
15	..	..	..	..	..	..	..	..
16	1	..	1	..	..	..	..	..
17	1	..	..	..	..	..	..	..
18	..	..	1	2	..	..	..	..
19	..	..	..	1	..	..	..	..
20	..	..	2	3	..	..	..	1
21	..	..	4	..	..	1	..	..
22	..	..	3	..	..	1	..	..
23	..	..	..	..	..	..	..	..
24	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..
26	..	..	..	..	..	..	2	..
Total number examined	3	1	11	6	..	2	2	1
Average length	15.3	12.0	20.4	19.2	..	21.5	26.0	20.0

Time of capture: April 14th—23rd, 1935.

5. Viviparous blenny (*Zoarces viviparus* L.).

21 specimens examined, 14 of which with stomach contents.

The viviparous blenny is a crustacean-gasteropod-fish-feeder. *Crustaceans*, more particularly *Idothea viridis* and *Leander adspersus* make up the bulk of its food. But furthermore the richness of small gasteropods is apparently utilized better by the viviparous blenny than by any other fish of the Fjord. *Cardium exiguum* is the only bivalve found in the stomach contents and in small numbers at that.

Gasterosteus pungitius is the only fish found in the stomach contents, of the total weight amount of which it makes up about 8 % or nearly as much as bivalves and gasteropods together.

Neither worms nor larvae of insects occurred in the stomachs.

The numbers of viviparous blenny having devoured the different food animals are as follows:

Cardium exiguum	1	*Gammarus locusta*	1
Hydrobia ulvae	4	*Idothea viridis*	11
Rissoa sp.	3	*Leander adspersus*	3
Littorina rudis	4	*Gasterosteus pungitius*	3

Also in the case of the viviparous blenny the age was determined by the zones of the otoliths. The lengths of the different age groups will appear from the following survey:

Numbers of individuals of the lengths in question.

	II-Group		III-Group		IV-Group	
Length in cms.	♀	♂	♀	♂	♀	♂
16	..	1	..	..	..	..
17	1	..	..	..	..	..
18	..	..	..	..	..	..
19	..	1	..	..	..	..
20	1	1	..	..	..	..
21	..	..	..	..	..	..
22	..	1	..	..	..	..
23	..	1	..	..	..	..
24	1	1	..	..	..	..
25	1	..	..	..	..	..
26	..	..	..	2	..	..
27	2	..	..	1	..	..
28	..	..	2	..	..	..
29	..	..	1	..	..	..
30	..	..	..	..	..	1
31	..	..	..	..	..	..
32	..	..	..	..	..	..
33	..	..	..	..	1	..
Total number examined	6	6	3	3	1	1
Average length	21.7	20.7	28.3	26.3	33.0	30.0

Time of capture: April 14th—20th, 1935.

6. Black Goby (*Gobius niger* L.).

34 specimens examined, 15 of which with stomach contents.

The black goby is decidedly a crustacean-feeder. Of the total weight of the stomach contents *Leander adspersus* constitutes more than half, and *Gammarus locusta* and *Idothea viridis* occur in most stomachs. The frequency of occurrence is:

Gammarus locusta	6
Aoridae	1
Idothea viridis	5
Mysis sp.	4
Leander adspersus	3

The growth of the goby was not studied in detail because a material of scales collected turned out to be unfitted for an age determination.

7. Roach (*Leuciscus rutilus* L.).

41 specimens examined, 14 of which with stomach contents.

The roach is decidedly a mollusk-feeder. But on account of the careful mastication and mixing up of the different food matters it was impossible to separate individuals for the weighings. In Table 1, therefore, the food animals met with in the stomach contents are only marked down with a cross. The following small survey shows in how many cases the different mollusks occur in the stomachs.

Mytilus edulis	2	*Littorina rudis*	9
Cardium exiguum	7	*Neritina fluviatilis*	2
Hydrobia ulvae	9	*Limnaea ovata*	1

The age of the roach was determined by the winter zones of the scales. Their growth in the Fjord is noteworthy, being the second best found in this country. Only the roach of the Hampen Sø show a more rapid growth (Otterstrøm 1930—31).

In the survey below the average length (in cms.) of the age groups of the Dybsø Fjord is compared with the average lengths in other brackish waters and in the Hampen Sø. The bracketed figures in the Dybsø Fjord column denote the numbers of roaches within the group in question.

The growth figures of the Randers Fjord were taken from Johansen & Løfting (1919), those of the Ringkøbing Fjord, Nissum Fjord, Sdr. Lem Vig, and Hampen Sø from Otterstrøm (1930—31).

It is an obvious supposition that the comparatively rapid growth of the roach from the II-Group, perhaps even from the I-Group, is due to these fish principally (in the cases examined: exclusively) feeding on mollusks, the nutritive value of which, according to Otterstrøm (1930—31), is particularly high. In freshwater we find a similar rapid growth when the roach passes from the poorer diet of plankton, chain-forming diatoms, etc., to that of mollusks. But this takes place at a later stage because the mollusks preferentially preyed upon (*Limnaea* species) require a certain size of the fish (about 20 cms.). This condition does not exist in the Dybsø Fjord where the mollusks in question are of so inferior size, that even small roach are able to utilize their nutritive value.

	0-Group		I-Group		II-Group		III-Group		IV-Group	
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Dybsø Fjord	..	..	..	..	..	15 (4)	22 (7)	21 (4)	24 (10)	22 (6)
Nissum Fjord	..	..	..	..	9	..	10—13	..	14—15	..
Ringkøbing Fjord	2.5	..	4.2	..	7.2	..	11.3	..	15.1	..
Sdr. Lem Vig	..	..	..	..	..	..	..	..	..	..
Randers Fjord	2.6	2.6	5.9	5.9	..	..	..	..	..	..
Hampen Sø	..	..	..	..	..	..	..	..	25	..

	V-Group		VI-Group		VII-Group		VIII-Group		IX-Group	
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Dybsø Fjord	26 (1)	25 (1)	..	..	..	..	..	..	..	..
Nissum Fjord	16	..	17—20	..	21—22	..	..	..	..	..
Ringkøbing Fjord	18.7	..	21.8	..	23—25	..	24—27	..	25—26	..
Sdr. Lem Vig	..	..	15—16	..	19—21	..	19	..	27	..
Randers Fjord	..	..	..	..	..	..	..	..	..	..
Hampen Sø	24—27	..	31—33	..	..	..	..	..	..	..

V. The Proportion between the Percentage Weight Amount of the Invertebrates per 1 sq. m. of the Fjord and Their Percentage Weight Amount of the Fish Stomachs.

The division sum

$$\frac{\text{percentage weight amount of the species per 1 sq. m. of the Fjord}}{\text{percentage weight amount of the species in the fish stomachs}}$$

gives the figures put down in Table 2. When no figure is given, the animal does not occur in the stomach contents. The more the result of the division approaches the size 0, the better is the animal turned to account except in such cases, what must be considered probable for *Mya*, *Arenicola*, *Leander*, and *Crangon*, when the technique of catching has failed.

The case of the proportion being = 1 or less than 1 depends exclusively on the breeding of the food animals.

It was already mentioned that *Idothea viridis* is the animal utilized to the highest degree. Next to it come *Gammarus locusta* and *Leander adspersus*.

Table 2.

The proportion between the percentage weight amount of the invertebrates per 1 sq. m. of the Fjord and their percentage weight amount in the stomach content of:

	Eel	Flounder	Cod	Viviparous blenny	Sea scorpion	Black goby
Mytilus edulis	..	×	..	..	..	..
Cardium exiguum	35.50	0.11	..	3.18	..	..
Cardium edule	..	1.03	..	..	..	..
Macoma baltica	..	7.56	..	..	..	..
Mya arenaria	..	..	..	..	..	..
Hydrobia ulvae	98.25	9.83	78.60	0.70	..	..
Rissoa sp.	..	8.67	21.67	2.28	65.00	..
Littorina rudis	428.00	71.33	71.33	3.27	11.82	..
Neritina fluviatilis	2.53	..	..	..	8.40	..
Limnaea ovata	0.09	..	..	..	..	..
Gammarus locusta	0.10	0.13	0.07	0.80	0.22	0.02
Aoridae	5.00	..	..	..	..	0.23
Corophium volutator	..	18.00	..	..	..	..
Sphaeroma rugicauda	..	..	..	..	..	..
Idothea viridis	0.06	0.03	0.15	0.05	0.38	0.11
Iaera marina	..	..	..	..	..	..
Cyathura carinata	1.00	..	..	..	2.50	..
Mysis sp.	..	1.20	..	..	1.50	0.01
Leander adspersus	0.04	1.28	0.05	0.02	0.02	0.02
Crangon vulgaris	0.05	0.20	0.01	..	0.02	..
Nereis diversicolor	..	..	..	..	..	..
Arenicola marina	0.05	..	..	..	..	..
Oligochaeta	..	..	..	..	..	..
Rhyncocoela	..	..	..	..	..	..
Turbellaria	..	..	..	..	..	..
Orthetrum cancellatum	..	..	..	..	0.23	..
Ischnura elegans	..	..	..	..	..	..
Haemonia mutica	..	..	..	..	..	..
Haliplus obliquus	..	..	..	..	..	..
Chironomidae	56.67	0.28	..	..	42.50	..
Oecetis ochracea	1.00	..	..	..	..	..

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Table I. Number and weight (in mg

Station number	2	3	4	5	6	7	8
Number of samples of $^1/_{44}$ sq. m.	7	10	10	10	10	10	10
Depth of water in m	0.50	0.50	0.85	0.90	1.15	1.50	0.50
Nature of bottom	Detritus mixed with sand	Detritus mixed with sand	Detritus mixed with sand	Clodded detritus mixed with sand	Clodded detritus mixed with sand	Detritus mixed with sand	Black detrit mixed wit tand
Vegetation	None	Scattered Chara	Chara	Scattered Chara	Chara	Thick Chara	Zannichelli sp.
Salt ‰	11.7	12.6	12.8	13.0	13.2	13.4	13.1
Datum	$^5/_6$ 34	$^5/_6$ 34	$^6/_6$ 34	$^6/_6$ 34	$^6/_6$ 34	$^6/_6$ 34	$^7/_6$ 34

	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	We
Mytilus edulis	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cardium exiguum	..	..	..	..	13.2	440	13.2	440	13.2	440	154.0	3 520	4.4	2
Cardium edule	..	..	..	..	162.8	18 040	176.0	36 080	136.4	19 360	105.6	14 080	..	..
Macoma baltica	..	..	17.6	6 160	167.2	38 280	171.6	65 120	506.0	91 960	321.2	53 900	..	..
Mya arenaria	..	..	..	..	4.4	220	30.8	15 400	8.8	2 860	..	..	..	..
Limnaea ovata	..	..	..	..	4.4	220	8.8	880	..	..	..	..	..	..
Gammarus locusta	..	..	4.4	4	..	..	..	..	4.4	9	17.6	361	4.4	5
Melita palmata	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Microdeutopus gryllotalpa	..	..	..	..	..	..	..	..	..	..	44.0	92	..	..
Corophium volutator	76.8	1 280	585.2	6 160	..	..	..	..	..	..	..	..	330.0	3 9
Sphaeroma rugicauda	..	..	..	..	..	..	..	..	..	..	..	..	4.4	
Idothea viridis	..	..	4.4	66	8.8	70	8.8	176	13.2	220	13.2	290	22.0	5
Iaera marina	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cyathura carinata	..	..	..	..	..	..	..	..	8.8	26	..	..	..	..
Mysis vulgaris	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mysis flexuosa	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Leander adspersus	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Nereis diversicolor	294.4	4 480	92.4	3 520	17.6	1 320	8.8	880	..	..	..	..	470.8	11 8
Arenicola marina	..	..	..	..	..	..	..	..	8.8	2 200	..	..	..	..
Oligochaeta	6.4	6	17.6	31	..	..	..	..	..	..	..	..	52.8	1
Rhynchocoela	..	..	..	..	..	..	..	..	8.8	440	8.8	440	..	..
Orthetrum cancellatum	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ischnura elegans	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oecetis ochracea	..	..	4.4	18	4.4	22	8.8	119	..	..	..	..	..	..
Haemonia mutica	..	..	..	..	..	..	4.4	66	..	..	..	..	..	..
Chironomidae	57.6	384	13.2	26	13.2	40	4.4	26	..	..	189.2	1 382	215.6	9

q. m. at the bottom sampler stations.

9		10		11		12		13		14		15		16		17	
10		10		10		5		10		10		10		10		10	
0.90		1.40		1.60		0.15		0.70		1.40		1.90		1.90		1.40	
black detritus mixed with sand		Black detritus mixed with sand		Black detritus mixed with sand		Soft black detritus mixed with sand		Black detritus mixed with sand		Soft black detritus mixed with sand		Detritus mixed with sand		Detritus mixed with sand		Detritus mixed with sand	
ck Chara d green orm algae		Thick Chara		Thick Chara		Zannichellia and green filiform algae		Chara and green filiform algae		Thick Chara and green filiform algae		Chara		Scattered Chara		Chara	
13.2		13.4		13.5		12.5		13.3		13.4				13.2		13.3	
$^{8}/_{6}$ 34		$^{8}/_{6}$ 34		$^{8}/_{6}$ 34		$^{9}/_{6}$ 34		$^{9}/_{6}$ 34		$^{9}/_{6}$ 34		$^{9}/_{6}$ 34		$^{11}/_{6}$ 34		$^{11}/_{6}$ 34	
er	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
8	1 100	96.8	3 080	167.2	3 520	..	..	70.4	2 640	70.4	2 640	35.2	880	118.8	1 760	96.8	2 640
0	34 760	110.0	4 840	162.8	29 920	..	..	57.2	8 800	70.4	2 640	83.6	2 200	237.6	17 160	246.4	16 720
6	68 200	545.6	77 440	316.8	48 840	..	..	387.2	42 240	567.6	52 800	233.2	32 120	26.4	14 520	66.0	19 360
	..	..	..	8.8	1 760	..	..	..	..	..	..	..	..	8.8	4 840	30.8	6 600
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	4.4	18	22.0	1 254	..	..	4.4	13	..	..	..	..	35.2	629	13.2	70
6	176	13.2	106	..	..	..	..	17.6	141	..	..	8.8	68	..	..	..	..
2	26	8.8	44	..	..	..	..	4.4	13	..	..	..	..	13.2	79	4.4	4
	..	..	..	..	..	1 355.2	17 800	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	8.8	214	..	..	..	..	..	..	..	..	..	..
4	44	39.6	616	58.2	1 043	..	..	8.8	150	8.8	88	13.2	216	8.8	66	35.2	537
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4.4	4
	..	..	..	..	..	..	..	..	..	..	..	..	..	4.4	84	22.0	172
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	4.4	136	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	4.4	1 100	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	765.6	24 030	4.4	4	..	..	8.8	440	8.8	440	4.4	220
6	3 520	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	26.4	40	..	..	..	..	..	..	..	..	8.8	13
4	1 320	26.4	1 760	..	..	..	..	66.0	3 960	22.0	440	8.8	660	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	4.4	88	..	..	4.4	48	8.8	128	..	..	..	..	8.8	88
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
8	4	233.2	1 496	74.8	449	35.2	214	4.4	13	35.2	185	4.4	9	26.4	154	61.6	163

Table I (continued). Number and weight (in m

Station number	18		19		20		21		22		23		24	
Number of samples of $^1/_{44}$ sq. m.	7		10		10		10		10		10		10	
Depth of water in m	0.50		2.00		1.10		0.15		0.25		0.10		1.25	
Nature of bottom	Pebbled detritus mixed with sand		Soft fetid black detritus		Sand		Black detritus mixed with sand		Sand		Sand		Detritus mixed wi sand	
Vegetation	None		Thick Chara and green filiform algae		Scattered Chara and green filiform algae		None		None		None		Green filiform alg Zostera	
Salt ‰	13.7		13.3		12.8		13.0		12.7		12.7		12.6	
Datum	$^{12}/_6$ 34		$^{12}/_6$ 34		$^{15}/_6$ 34		$^{15}/_6$ 34		$^{15}/_6$ 34		$^{15}/_6$ 34		$^{15}/_6$ 34	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	We
Mytilus edulis	..	..	4.4	880	88.0	6 600	4.4	1 320	..	..	..	..	475.2	65
Cardium exiguum	..	..	44.0	440	70.4	880	..	..	..	..	..	..	48.4	1
Cardium edule	6.4	1 280	83.6	2 640	242.0	40 040	4.4	440	61.6	14 960	52.8	11 000	127.6	7
Macoma baltica	..	..	17.6	11 440	74.8	22 880	111.2	26 400	96.8	56 320	264.0	55 880	127.6	57
Mya arenaria	..	..	..	..	..	..	..	..	..	..	4.4	1 320	..	
Limnaea ovata	..	..	..	..	..	..	..	..	..	..	..	..	..	
Gammarus locusta	6.4	58	35.2	110	8.8	220	4.4	35	..	..	..	..	22.0	
Melita palmata	..	..	8.8	57	..	..	..	..	..	..	..	..	30.8	
Microdeutopus gryllotalpa	..	..	22.0	114	4.4	9	..	..	..	..	..	..	39.6	
Corophium volutator	115.2	640	..	..	..	..	13.2	48	4.4	22	4.4	22	..	
Sphaeroma rugicauda	..	..	..	..	..	..	..	..	..	..	..	..	..	
Idothea viridis	25.6	435	35.2	571	35.2	277	52.8	682	4.4	57	..	..	22.0	
Iaera marina	..	..	..	..	..	..	..	..	..	..	..	..	..	
Cyathura carinata	..	..	4.4	18	..	..	..	..	..	..	..	..	..	
Mysis vulgaris	..	..	..	..	..	..	..	..	4.4	22	..	..	..	
Mysis flexuosa	..	..	..	..	..	..	..	..	..	..	..	..	..	
Leander adspersus	..	..	..	..	..	..	..	..	..	..	..	..	..	
Nereis diversicolor	19.2	640	..	..	13.2	440	211.2	7 920	57.2	6 600	118.8	3 520	13.2	
Arenicola marina	..	..	..	..	..	..	..	..	8.8	2 640	22.0	3 520	..	
Oligochaeta	..	..	..	..	..	..	4.4	4	..	..	..	..	..	
Rhynchocoela	..	..	4.4	4	4.4	53	..	..	..	..	..	..	8.8	
Orthetrum cancellatum	..	..	..	..	..	..	4.4	1 826	..	..	..	..	..	
Ischnura elegans	..	..	..	..	..	..	4.4	167	..	..	..	..	..	
Oecetis ochracea	..	..	4.4	22	..	..	..	..	..	..	..	..	..	
Haemonia mutica	..	..	..	..	..	..	..	..	..	..	..	..	22.0	
Chironomidae	19.2	141	770.0	2 116	26.4	136	4.4	22	4.4	18	8.8	13	17.6	

r sq. m. at the bottom sampler stations.

25	26	27	28	29	30	31	32
10	10	10	10	4	10	10	10
1.50	0.25	0.15	1.25	0.50	0.30	0.50	0.35
Detritus mixed with sand	Sand mixed with detritus	Black detritus	Gravel	Black detritus	Sand	Sand	Sand
ttered Chara and green liform algae	Scattered Chara	Chara and green filiform algae	Scattered Chara and green filiform algae	Thick Chara	Scattered Ruppia	Scattered Ruppia and Zostera	Scattered Ruppia
13.7	13.8	12.9	13.0	13.3	13.3	13.3	12.5
$^{18}/_{6}$ 34	$^{18}/_{6}$ 34	$^{18}/_{6}$ 34	$^{19}/_{6}$ 34	$^{19}/_{6}$ 34	$^{19}/_{6}$ 34	$^{19}/_{6}$ 34	$^{19}/_{6}$ 34
mber Weight	Number Weight	Number Weight	Number Weight	Number Weight	Number Weight	Number Weight	Number Weight
.. ..	.. ..	.. ..	4.4 440	.. ..	.. ..	.. ..	.. ..
22.0 440	.. ..	.. ..	96.8 1 320	11.0 500	.. ..	.. ..	.. ..
23.2 12 760	52.8 15 400	17.6 6 160	316.8 21 560	231.0 24 420	506.0 37 840	101.2 17 600	17.6 7 040
61.6 22 440	180.4 39 600	4.4 3 520	8.8 2 200	220.0 52 170	8.8 3 960	74.8 12 760	83.6 16 280
.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	4.4 2 200	13.2 6 600
.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
8.8 22	4.4 26	.. ..	8.8 286	.. ..	.. ..	.. ..	4.4 53
.. ..	.. ..	.. ..	.. ..	44.0 56	.. ..	.. ..	.. ..
.. ..	.. ..	.. ..	8.8 40	.. ..	.. ..	.. ..	.. ..
.. ..	.. ..	22.0 154	.. ..	.. ..	8.8 31	.. ..	.. ..
.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
13.2 242	22.0 440	22.0 339	8.8 286	55.0 1 010	4.4 57	4.4 123	4.4 84
.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
.. ..	61.6 691	.. ..	8.8 132	.. ..	.. ..	.. ..	.. ..
.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
.. ..	17.6 2 640	13.2 1 760	4.4 106	.. ..	26.4 1 320	22.0 1 320	83.6 6 160
.. ..	4.4 880	.. ..	.. ..	.. ..	.. ..	.. ..	4.4 18
.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
.. ..	13.2 1 320	4.4 440	.. ..	132.0 8 480	.. ..	.. ..	.. ..
.. ..	.. ..	17.6 1 026	.. ..	.. ..	.. ..	.. ..	.. ..
.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
.. ..	4.4 141	17.6 405	.. ..	.. ..	4.4 114	.. ..	.. ..
22.0 66	8.8 22	83.6 220	8.8 18	8 118.0 26 529	13.2 44	13.2 48	17.6 57

Table II. Number and weight (in mgs.

Station number	I		II		III		IV		V		VI		VII		VIII	
Number of samples of 1 sq.m.	2		2		2		2		2		2		2		2	
Depth of water in m.	1.00		1.00		1.00		1.00		0.50		1.25		1.35		1.00	
Nature of bottom	Detritus mixed with sand		Detritus mixed with sand		Detritus mixed with sand		Detritus		Sand		Detritus		Sand		Detritus mixed with sand	
Nature and tallness (in cms.) of the vegetation	Thick green filiform algae, 7—10 cms.		Chara, 10 cms.		Chara, 10—15 cms.		Thick Chara, 10 cms.		Scattered Chara		Thick Chara, 15—20 cms.		Scattered Chara, 10 cms.		Thick Chara, 10 cms.	
Datum	$^{17}/_{5}$ 35		$^{17}/_{5}$ 35		$^{17}/_{5}$ 35		$^{17}/_{5}$ 35		$^{17}/_{5}$ 35		$^{18}/_{5}$ 35		$^{18}/_{5}$ 35		$^{18}/_{5}$ 35	
	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
Mytilus edulis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.0	3
Cardium exiguum	8.5	232	10.0	168	27.0	588	17.0	481	5.0	16	..	..	18.5	344	21.0	448
Cardium edule	14.5	38	11.0	59	15.0	98	14.0	986	40.0	1 480	..	..	4.0	350	1.0	188
Macoma baltica	..	..	1.5	312	1.0	367	..	..	..	..	..	..	1.0	203	..	..
Hydrobia ulvae	..	1 740	..	1 131	..	1 740	37.0	88	..	2 262	..	741	..	7 305	..	3 053
Rissoa sp.	1.0	16	..	..	2.5	33	1.0	13	0.5	2	0.5	3	25.5	269	95.5	1 066
Littorina rudis	10.0	281	96.0	1 800	69.0	2 203	32.0	2 375	18.5	219	0.5	22	..	3 265	..	2 403
Neritina fluviatilis	1.0	28	14.5	273	6.5	108	9.5	275	0.5	5	1.0	63	48.0	918	27.0	653
Limnaea ovata	..	..	..	..	..	..	23.5	2 647	..	..	..	..	0.5	103	..	..
Gammarus locusta	0.5	31	..	..	0.5	17	0.5	13	..	..	..	..	..	..	..	..
Aoridae	0.5	3	0.5	1	..	..	2.5	5	0.5	1	4.0	18	3.5	10	..	..
Idothea viridis	1.0	23	10.5	127	23.5	296	2.5	32	8.0	89	13.0	295	10.5	116	20.5	382
Iaera marina	..	..	..	..	..	..	..	..	1.0	1	..	..	..	..	..	..
Mysis sp.	3.0	152	1.0	27	0.5	19	0.5	15	1.5	57	0.5	43	2.5	115	1.5	39
Leander adspersus	0.5	268	1.5	613	2.0	897	0.5	168	..	..	2.5	510	0.5	232	2.0	537
Crangon vulgaris	..	..	..	..	..	..	..	..	1.5	536	..	..	0.5	272	..	..
Nereis diversicolor	1.5	24	..	..	2.5	8	0.5	25	0.5	3	..	..	..	..	1.0	6
Rhynchocoela	..	..	..	..	1.0	62	..	..	..	..	..	..	..	..	..	..
Turbellaria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oecetis ochracea	..	..	0.5	2	1.0	2	..	..	..	..	..	..	..	..	..	..
Haemonia mutica	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Haliplus obliquus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Chironomidae	1.0	2	1.5	1	3.0	6	1.0	1	..	..	3.5	42	..	..	..	..
Gobius niger	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
— *minutus*	..	..	..	..	..	..	..	..	..	..	..	..	0.5	183	..	..
Gasterosteus aculeatus	..	..	..	..	..	..	..	..	0.5	536	..	..	..	..	..	..
— *pungitius*	1.0	304	..	..	..	..	0.5	163	..	..	0.5	343	0.5	157	..	..

r sq. m. on the hand net stations.

IX		X		XI		XII		XIII		XIV		XV		XVI		XVII	
2		2		2		2		2		1		2		2		2	
1.25		1.60		1.25		1.10		1.50		0.30		0.75		1.60		0.80	
Detritus mixed with sand		Detritus mixed with sand		Detritus mixed with sand		Detritus mixed with sand		Detritus mixed with sand		Sand		Sand		Detritus mixed with sand		Detritus	
Thick Chara, 10—15 cms.		Chara, 10—15 cms.		Green filiform algae, 10 cms.		Thick Chara, 10 cms.		Thick Chara, 15 cms.		Scattered Zostera and Fucus		Scattered Fucus		Chara, 5—10 cms.		Thick Chara, 50 cms.	
19/5 35		19/5 35		19/5 35		20/5 35		21/5 35		21/5 35		21/5 35		21/5 35		21/5 35	
No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
..	..	..	..	..	..	4.0	197	0.5	448	..	14 789	22.0	3 822	..	..	..	..
11.0	89	22.0	295	..	987	14.5	432	17.0	292	..	3 156	..	894	12.5	176	4.5	203
5.5	20	..	..	10.0	966	7.0	661	2.0	278	57.0	4 140	..	1 149	..	..	..	..
..	..	..	..	..	..	..	..	..	..	2.0	1 084	0.5	93	..	..	..	..
..	413	52.5	209	15.0	31	..	802	..	1 265	..	17 847	..	4 783	..	787	..	1 005
2.0	20	1.0	16	1.5	10	6.5	101	45.0	366	..	9 274	..	3 390	..	361	2.0	16
..	1 925	43.5	1 036	19.0	705	..	5 312	..	1 570	..	13 985	..	6 388	..	641	..	5 195
13.0	209	2.0	55	3.5	115	34.5	889	1.5	35	12.0	287	..	754	13.0	145	3.0	53
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2.5	191
..	..	..	..	2.5	81	1.5	45	1.0	52	52.0	2 065	21.0	137	..	..	4.0	111
1.5	9	5.5	20	15.5	52	5.0	21	2.5	8	38.0	103	41.0	158	1.0	5	3.5	9
24.5	565	15.5	111	5.0	114	40.0	915	6.0	100	111.0	2 897	59.5	1 529	4.5	75	28.5	786
..	..	0.5	2	0.5	1	..	..	..	..	7.0	7	3.0	8	..	..	..	..
3.5	76	..	..	6.5	295	3.0	126	..	..	..	..	4.5	227	1.0	44	2.5	136
1.0	511	0.5	109	1.0	464	0.5	63	2.0	1 449	7.0	3 826	2.0	1 428	0.5	236	1.0	232
0.5	171	..	..	..	..	..	..	..	..	1.0	200	4.5	1 537	2.5	438	..	..
..	..	0.5	3	1.5	63	3.0	74	..	..	5.0	124	4.0	124	..	..	..	..
0.5	9	..	..	3.0	209	..	..	..	..	9.0	243	2.0	40	..	..	..	..
..	..	..	..	8.0	35	2.0	13	..	..	4.0	18	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	2.0	20	..	..	..	..	..	..
..	..	..	..	..	..	1.5	5	..	..	..	..	..	..	..	..	..	..
1.5	7	0.5	1	0.5	2	30.5	387	..	..	..	..	..	..	..	..	1.0	5
..	..	..	..	..	..	..	..	..	..	1.0	3 620	..	..	..	..	..	..
..	..	..	..	..	..	0.5	193	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1.0	454	1.0	432	..	..	1.0	513	1.0	293	1.0	400	1.0	410	..	..	0.5	306

On the Production of Matter and the Growth in some Benthic Plants.

By

SØREN LUND

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In a paper on the valuation of the sea (Petersen & Boysen Jensen, 1911) C. G. Joh. Petersen proposes to "bring the plant belt under quantitative treatment" (p. 69), being of opinion that it is the benthos flora which is "the basis of the fish-life in the Limfjord and certainly in many other coastal waters" (p. 70). Already at an earlier date (1890) the same author had advanced the opinion that the richness of fish at our coasts is principally due to the eel-grass. Up to now, however, the literature does not contain much information on the production of matter in the plants of the sea bottom, neither in this country nor abroad.

I. Earlier Investigations.

A. The production of matter in *Zostera marina*.

The principal work on eel-grass, *Zostera*, is C. G. Joh. Petersen "Om Bændeltangens (*Zostera marina*) Aars-Produktion i de danske Farvande" (1913). Here the annual number of leaves on each shoot of this plant is put at about 15, viz. about 10 leaves in summer and 5 in winter. According to Ostenfeld (1908) each rhizome produces only 4 to 6 leaves a year (this being meant as a hypothesis only). In the "Watten-Zee" of Holland Van Goor (1920) found an annual production of 4 to 7 leaves.

According to the above-mentioned paper by Petersen the momentary stock of *Zostera*-leaves reaches its culmination in July-September. In favourable places the weight of the maximum quantity was found to be about 6000 gms., in moderately good places about 3500 gms., and in bad places about 1700 gms. per 1 sq. m. When the percent of dry matter of *Zostera* is estimated at 16 (p. 15), the weight of dry matter per 1 sq. m. will be respectively 960, 560, and 272 gms. — In the Gullmar Fjord on the west coast of Sweden Gislén (1930, p. 134) in putting the percentage of dry matter of *Zostera* at 11.4 (p. 131) in July-August found a average momentary weight of dry matter of 521 gms. per 1 sq. m. (rhizomes and roots included). If the other plants and the animals of the association were included, the average weight of dry matter would be 577 gms. per 1 sq. m.

According to Petersen (1918, Plate XI) the weight of the total stock of *Zostera* in the Kattegat during the summer is 24 mill. tons = about 4 mill. tons of dry matter.

Petersen (1913, p. 15) calculates the annual production of *Zostera* leaves in Danish waters to be 1920, 1120, and 544 gms. of dry matter per 1 sq. m. in respectively favourable, moderately good, and bad growing places. In putting the average of the annual *Zostera* production per 1 sq. m. at 1120 gms. of dry matter Boysen Jensen (1914, p. 17) arrives at the result that in the waters from inside the Skaw to the Baltic (the line Gedser—Darsserort) — $^1/_7$ of which area is covered with *Zostera* — the annual production of this plant would be 120 gms. of organic dry matter (dry matter minus ashes) per 1 sq. m. of these waters taken as a whole.

The total annual production of eel-grass in the Danish waters inside the Skaw is estimated by Petersen (1913, p. 17) at 8,232 mill. tons of dry matter.

B. The production of matter in marine algae.

One of the first works touching on the production of matter in marine algae is Videment "Les herbes marines" (1909). In this work we find information on the quantities of algae (+ other marine plants) accumulated and brought ashore every year on the coasts of France. On the basis of this paper Peter-

sen (1912) calculated the quantity of algae brought ashore annually from Blainville to Noirmoutier to represent an amount of 267 mill. kgs. of dry matter. In these two papers, however, we find no numerical expression for the weight of the momentary stocks or the annual production of a certain area.

An important work concerning the momentary stock is a paper by Gislén on the epibioses of the Gullmar Fjord (1930). The paper gives a survey of the weight of the average momentary stock (July-August) per 1 sq. m. of the different associations of this fjord, expressed on the basis of both weighings of the fresh material (p. 113—114) and of calculations of the weight of dry matter (p. 134—135). In each sample regard is paid to both plants and animals, and as far as possible the individual species were weighed separately (p. 211—304). In the synopsis of the associations on p. 134—135 we therefore find the average weight of dry matter both in the characteristic species (plant or animal) and in the rest of the association (plants + animals) per 1 sq. m. As an instance may be mentioned that in the *Fucus spiralis* association the weight of dry matter is for the characteristic species alone 1.10 kg., for the whole association 1.25 kg. per 1 sq. m. For *Fucus vesiculosus* the corresponding figures are 1.51 and 1.85, for *F. serratus* 2.04 and 2.27, and for *Ascophyllum* 4.05 and 4.16. For *Laminaria* the figures are: *L. digitata* 1.62 and 1.79, *L. saccharina* 0.58 and 0.89, and *L. hyperborea* 0.68 and 0.79.

On the Murman Coast of the Barent Sea Kireeva & Schapova (1933)[1]) found the following figures for the weight of the average momentary stock of marine algae per 4 sq. m. of the *Laminaria* region: Olenia Bay, 4—6 metres, *Laminaria saccharina* zone: 21.3 kgs. (July, 2nd—4th); Vtoroi Dvor, 2.5—4.5 metres, *L. digitata* zone: 28.09 kgs. (July, 6th—7th); Kildin Island, 3—4.5 metres, *L. saccharina*, *L. digitata*, and *Alaria esculenta* zone: 28.37 kgs. (July, 10th—11th). In the littoral region of Pala Bay the weight of the average momentary stock of the *Fucus vesiculosus* zone was 9.9 kgs. per 1 sq. m. (July, 28th—August, 2nd); in the littoral region of Katherine Harbour the stock of the *Ascophyllum nodosum* zone amounted to 18.7 kgs. per 1 sq. m. (July, 7th—August, 2nd). All these figures originate from weighings of fresh material.

[1]) For the translation of the Russian text in the chapter on productivity and growth in this paper I am much indebted to Magister Thorvald Sørensen.

The total stock of marine algae in the White Sea is estimated by Meyer (1933) at $1^1/_2$ mill. tons (raw weight).

We know very little about the annual production of matter in the marine algae. In the case of the Danish waters Kolderup Rosenvinge (1911) supposes that it is "more than the half, and probably much more than the half of the algal mass present at any time" (p. 11) even if the loose algae are included. This hypothesis is based on a comparison between the total mass of algae obtained in the dredge respectively in January and in summer.

As regards the Gullmar Fjord Gislén (1930, p. 121) advances the supposition that the weight of the maximum momentary stock of those associations the characteristic species of which is restricted to a certain season of the year ("seasonal associations") varies between at least 0.5 and 5 kgs. per 1 sq. m. (weight of fresh material) and that the annual production is often higher. The annual organic production of the region of *Fucaceæ* is estimated at about 1 kg. (p. 142). The production during the first year of a young *Fucus vesiculosus* association would correspond to about half the weight of the momentary stock of this association (p. 124).

C. The growth of *Fucus*.

In November Hariot (1909, p. 353) scraped bare some rocks near St.-Vaast-la-Hougue which were covered with *Fucus vesiculosus* and *F. platycarpus*. He reports that in this place seedlings of *Fucus* were not observed until about the beginning of June. On July, 9th, these seedlings were 0.3—0.6 cm. long. From the basal part of adult individuals, the shoots of which had been cut off near the holdfast in November, new shoots began to appear in January; in July they were 4 to 5 cms. long. The average monthly growth of seedlings of *Fucus vesiculosus* at Roscoff in some of Mme Lemoine's experiments (1913, p. 3—4) amounted to 2.5—3.3 cms., in another experiment to 0.4—0.7 cm. Most experiments were carried out in summer. The monthly growth of *Fucus serratus*(?) was found to be 5 cms., some plants, developing between August, 15th and October, 30th, reaching a length of 12 cms. At Trøndelagen, where the fructification of *Fucus vesiculosus* takes place from the end of April till well into July, Printz (1926, p. 208) found the young plants of this species to be 3—5 cms. long after one winter (measured in March), 9—14 cms. after two winters, and 12—20 cms.

after three winters. For *Fucus serratus* the same author (p. 206) estimates the annual growth at 9—12 cms. in favourable growing places. The length of the branch-ends throwed off after the fructification amounts to 3—4 cms. In the Gullmar Fjord Gislén (1930, p. 124) found that seedlings of *Fucus vesiculosus* dating from May or June in December had attained a length of 6—14 cms. (breadth 0.8—1.5 cm.). In plants of *Fucus vesiculosus* and *F. serratus* that had been damaged by the ice new shoots would sometimes appear; in December the shoots of the former had a length of 8—12 cms. and a breadth of up to 0.6 cm., those of the latter a length of 14 cms. and a breadth of 1.5—2.5 cms. At Helgoland Nienburg (1930, p. 8—9) observed that seedlings of *Fucus* which were not older than from the month

Fig. 1.

of February had attained a length of about 5 cms. in the autumn. *Fucus vesiculosus* and *F. serratus* showed nearly the same growth rate during their first two years: seedlings dating from the spring grew up to be about 10 cms. during the first, and 20—25 cms. during the second year. During the third year the growth of *F. vesiculosus* was superior: in August of this year the plants of this species were 50—60 cms. long, *F. serratus* being at the same time about 40 cms. long.

II. Investigations Carried out by the Author.

A. The production of matter on a given area within a given time.

a. The production on concrete blocks put out for the purpose.

As a means of getting an impression of the production of matter in the marine algae of the Danish waters Dr. H. Blegvad, Director of the Danish Biological Station, advised me to put out a number of cubic concrete blocks (the height of which was 30 cms.; the area of a side consequently 900 sq. cms.) in various localities. The purpose was to mow the vegetation of one or several sides at certain intervals,

Table 1. Synopsis of the production on the concrete blocks.[1])

	Locality	Side of the block	Association	Other plants in the sample	Experimental period	Weight per 900 cm.²	Weight per 1 m.²
The Sound	Saltholms Flak, 1 m	Upper side	*Rivularia nitida*	*Polysiphonia violacea* (+ *nigrescens*)	$^{30}/_{3}$ 33—$^{13}/_{11}$ 33	0.3872 g	4.30 g
	—	vertical side a	—	—	—	0.7874 -	8.75 -
	—	— b	—	—	—	2.1588 -	23.99 -
	—	Upper side	*Rivularia nitida-Polysiphonia viol.*	*Ceramium, Fucus*-seedl., *Cladophora*	$^{13}/_{11}$ 33—$^{18}/_{10}$ 34	0.6282 -	6.98 -
	—	vertical side a	—	*Fucus*-seedl.	—	2.4083 -	26.76 -
	—	— b	*Polysiphonia viol.-Rivularia nitida*	*Polysiphonia nigrescens*	—	0.7583 -	8.43 -
	—	— c	—	—	—	0.4659 -	5.18 -
	—	— d	*Polysiphonia violacea*	*Rivularia nitida, Ceramium, Cladophora, Fucus*-seedl.	—	0.1203 -	1.34 -
Great Belt	Nyborg Fjord, 1 m	Upper side	*Fucus*	*Ectocarpus, Sphacelaria, Polysiphonia, Rhodomela, Ceramium*	$^{25}/_{3}$ 33—$^{28}/_{10}$ 33	2.7405 -	30.45 -
	—	vertical side a	*Fucus*(*-Ectocarpus-Sphacelaria*)	— + *Chorda filum*	—	2.4287 -[2])	36.80 -
	Between Slipshavn and Knudshoved, 3 m	Upper side	*Polysiphonia* (esp. *nigr.*)	*Rhodomela, Ceramium*, isolated *Fucus*-seedl., *Chorda fil., Ectocarpus, Sphacelaria*	$^{25}/_{3}$ 33—$^{28}/_{10}$ 33	0.6779 -	7.53 -
	—	vertical side a	*Polysiphonia nigr.* (*-Sphacel.*)	isolated *Fucus*-seedl.	—	0.4899 -	5.44 -
	—	— b	—	— + *Callithamnion*	—	0.5740 -	6.38 -
Little Belt	Geerhagen at Fænø, 1 m	Upper side	*Fucus*	*Ceramium, Polysiphonia, Callithamnion, Enteromorpha*	$^{24}/_{3}$ 33—$^{27}/_{10}$ 33	1.2789 -	14.21 -
	—	vertical side b	*Ceramium rubr.*	*Polysiphonia, Fucus*-seedl.	—	0.0599 -	0.67 -
	Fænø Kalv, 3 m	Upper side	*Polysiphonia-Ceramium-Fucus*	*Callithamnion, Enteromorpha*	$^{24}/_{3}$ 33—$^{27}/_{10}$ 33	1.0691 -	11.88 -
	—	vertical side a		*Rhodomela, Ceramium, Callithamnion, Fucus*-seedl., *Sphacelaria, Enteromorpha*	—	0.0214 -	0.24 -
	—	Upper side	*Polysiphonia nigr.-Rhodomela*	*Ceramium, Rhodymenia, Enteromorpha, Ectocarpus, Sphacelaria, Fucus*-seedl.	$^{27}/_{10}$ 33—$^{23}/_{7}$ 34	3.9530 -	43.92 -
	—	vertical side a	*Rhodymenia palmata* (*-Rhodomela*)	*Polysiphonia, Ceramium, Callithamnion, Laminaria*-seedl., *Ectocarpus*	—	8.95 -	99.44 -
	—	— c	*Rhodomela*	*Ceramium, Rhodymenia, Polysiphonia nigr., Fucus*-seedl., *Chorda fil., Ectocarpus*	$^{24}/_{3}$ 33—$^{23}/_{7}$ 34	7.5868 -	84.30 -

[1]) Of course the weight figures only give the approximate value of the production; part of the thallus of the algae may have fallen off during the experiment, and annual species may have disappeared completely.

[2]) Experimental area in this case 660 cm².

Table 2. Synopsis of the average production of the different associations per 1 m.², based on the production of an area of 900 cm².

Rivularia nitida-Ass.	Saltholms Flak, 1 m	$^{30}/_{3}$ 33—$^{13}/_{11}$ 33 = abt. $7^{1}/_{2}$ months		12.35 g.
Rivularia nitida-Polysiph. viol.-Ass.	—	$^{13}/_{11}$ 33—$^{18}/_{10}$ 34 = abt. 11 months		11.84 -
Polysiphonia violacea-Ass.	—	—		1.34 -
Polysiphonia nigrescens-Ass.	Between Slipshavn and Knudshoved, 3 m	$^{25}/_{3}$ 33—$^{28}/_{10}$ 33 = abt. 7	—	6.45 -
Polysiphonia nigr.-Rhodomela-Ass.	Fænø Kalv, 3 m	$^{27}/_{10}$ 33—$^{23}/_{7}$ 34 = abt. 9	—	43.92 -
Polysiphonia-Ceramium-Fucus-Ass.	—	$^{24}/_{3}$ 33—$^{27}/_{10}$ 33 = abt. 7	—	11.88 -
Rhodomela-Ass.	—	$^{24}/_{3}$ 33—$^{23}/_{7}$ 34 = abt. 16	—	84.30 -
Rhodymenia palmata(-*Rhodomela*)-Ass.	—	$^{27}/_{10}$ 33—$^{23}/_{7}$ 34 = abt. 9	—	99.44 -
Ceramium rubrum-Ass.	Geerhagen at Fænø, 1 m	$^{24}/_{3}$ 33—$^{27}/_{10}$ 33 = abt. 7	—	0.67 -
Fucus-Ass.	Nyborg Fjord, 1 m	$^{25}/_{3}$ 33—$^{28}/_{10}$ 33 = abt. 7	—	33.63 -
Fucus-Ass.	Geerhagen at Fænø, 1 m	$^{24}/_{3}$ 33—$^{27}/_{10}$ 33 = abt. 7	—	14.21 -

in order to be able to calculate their production within a given time. The placing of the blocks was carried out in the spring of 1933 and later. For the investigation were chosen the following localities: the reefs at Frederikshavn, Vorsø in the Horsens Fjord, Fænø and Fænø Kalv in the Little Belt, the Nyborg Fjord and another locality of the Great Belt (between Knudshoved and Slipshavn), and Saltholms Flak in the Sound. Some of the blocks put out disappeared, but were replaced by others later on. In Table 1 are given some preliminary results from the blocks put out in the Sound, the Great Belt, and the Little Belt. The algae were weighed, and besides this the species of the samples were analysed. The figures of the table, which originate from weighings of air-dried material[1]), are possibly a little low because the samples had been preserved for some time in a solution of 4 % formaldehyd. As far as possible the algae were cleared of animals and grains of sand before the weighings. It was impossible, however, to remove all small crustaceans, etc. Besides the weight per 900 sq. cms. is also given the corresponding weight per 1 sq. m. (the right-hand column).

As will appear from the table we find the greatest production in certain associations of red algae at the Fænø Kalv in the Little Belt at a depth of 3 metres: here the production amounted to 8.95 gms. within a time of about 9 months (27-X-33 to 23-VII-34) in a *Rhodymenia palmata*(-*Rhodomela*) association, 7.5868 gms. during about 16 months (24-III-33 to 23-VII-34) in a *Rhodomela* association, and 3.9530 gms. during about 9 months (27-X-33 to 23-VII-34) in a *Polysiphonia nigrescens-Rhodomela* association. In the Nyborg Fjord (1 m.) the production yielded in a *Fucus* association 2.7405 gms. in 900 sq. cms., in a *Fucus* (-*Ectocarpus-Sphacelaria*) association 2.4287 gms. in 660 sq. cms., the duration of both these experiments being about 7 months (25-III-33 to 28-X-33). At Saltholm the production was in one case 2.4083 gms. in a *Rivularia nitida-Polysiphonia violacea* association in the course of about 11 months (13-XI-33 to 18-X-34), in another 2.1588 gms. in a *Rivularia nitida* association during about $7^{1}/_{2}$ months (30-III-33 to 13-XI-33). Remarkably low figures are found in the statements from both Saltholm and the locality between Slipshavn and Knudshoved in the Great Belt as well as from Geerhagen and the Fænø Kalv in the Little Belt. One sample from the last-mentioned place only weighed 0.0214 gms. (24-III-33 to 27-X-33 = about 7 months).

So the weights stated are rather different. Not only do the figures of the production vary in the different localities, even where the same associations prevail: the production even varies within the same association of a certain locality. Therefore a survey is given in Table 2 of the average production of the different associations in the different localities calculated per 1 sq. m. on the basis of the production of 900 sq. cms.

The hydrographical conditions of the localities in question are dealt with in Table 3, which gives information on the salinity and temperature of the surface water in places situated near the localities of experiment (see the map). The figures were taken from the statements of Nautisk-Meteorologisk Aarbog 1932, 1933, and 1934. The experimental localities of the Little Belt and the one between Slipshavn and Knudshoved in the Great Belt — more particularly at Geerhagen and Fænø Kalv in the Little Belt — are exposed to rapid currents; this is not so conspicuous in the Nyborg Fjord although here, too, there is an ample renewal of water. A still more

[1]) Meaning material dried in the air to as high a degree as possible without the use of an exsiccator.

Table 3. Salinity and temperature of the surface water at 8 o'clock in places near the experimental localities.

		Salinity in ‰					Temperature				
		Average of the monthly mean figures	Minimum		Maximum		Average of the monthly mean figures	Minimum		Maximum	
			1933	1934	1933	1934		1933	1934	1933	1934
The Sound	The Middelgrund Fort..	1896-1930: 11.7	6.3	7.6	23.7	25.3	1896-1930: 8.4	0.0	1.4	19.2	19.5
	The Drogden L. V.....	1903-1930: 10.6	6.4	7.2	25.8	25.7	1881-1930: 8.2	÷ 0.5	1.4	18.5	19.2
Great Belt	Sprogø	1893-1922: 15.7	..	..	..	..	1893-1922: 8.4	..	..	..	..
	Halskov Reef L. V.....	1921-1930: 14.8	8.1	8.8	24.3	26.3	1921-1930: 8.5	÷ 0.1	1.6	18.8	19.9
Little Belt	Middelfart.....	1895-1930: 19.6	14.0	12.5	27.9	30.2	1895-1930: 8.4	0.9	2.6	18.8	19.3

limited exposure we find on the locality at Saltholm, the Saltholm Flak being a rather large shallow, and so the temperature of the surface water of this place is no doubt subject to greater fluctuations than at the Middelgrund Fort and the Drogden light-ship.

As to the vegetation of the experimental localities at the time when the blocks were put out the following facts may be stated. The Saltholm Flak: rather sparse but fairly uniform vegetation of *Fucus vesiculosus*; the Nyborg Fjord and Geerhagen at Fænø: here and there stones with *Fucus*; Fænø Kalv: *Laminaria*, *Chorda filum*, and red algae; ample vegetation. The locality between Slipshavn and Knudshoved: nearly no vegetation. All localities showed a hard sandy bottom, at the Saltholms Flak intermixed with some gravel.

b. Examination of light-buoys.

For the purpose of examining whether light-buoys can be used for experiments on the production of algae I asked the permission of Fyr- og Vagervæsenet (the Lighthouse Authorities) to make a trip with the inspection vessel "Absalon", and on May 14th, 1935 the following 4 light-buoys in Drogden were examined: Nordre Røse, Drogden 2, Drogden 4, and Drogdèn C. The buoys had been out for 10 to 13 months and on the whole they showed a very sparse vegetation (Drogden 4 nearly without vegetation). In and a little above the water-line, however, was often found a rather well-grown zone of green algae, in which *Urospora* sometimes played a considerable part. Below the water-line practically nothing but diatoms occurred though, in return, in rather considerable quantities; furthermore, this part of the buoys showed a sparse but uniform representation of barnacles, the shells of which now and then acted as the substratum of algae (*Acrosiphonia*, *Ectocarpus*, *Pylaiella*). On the lower part of the buoy Nordre Røse, at which place the water is 10 m. deep, were found some individuals of *Ceramium*, *Ectocarpus*, *Pylaiella*, and *Acrosiphonia*; on the mooring chain *Scytosiphon* occurred and on its

Table 4. Schematic survey of the experimental plants of *Fucus vesiculosus* on the Saltholms Flak.

Experimental plant no.	Date of observation	Approximate age at beginning of experiment	Description of the plant	Weight in air-dried condition	Weight increment during last year
1	$^{20}/_{10}$ 32	1 year or more	Undivided thallus; 4 cm. long (1.2 cm. broad).	0.048 g.	
	abt. 1 year later		Thallus with several bifurcations; 8.7 (1.4); wit 4 air vesicles. Near base abt. 10 small linear shoots (max. length 1.0).		
	abt. 2 years later		a: 3 bifurcations; 13.0 (1.4); each of new branches with 2 air vesicles; b: 4.5 (0.5); c: 3.5 (0.5). Further some base and side shoots.		
3	$^{20}/_{10}$ 32	More than 1 year	Undivided thallus; 6.4 (1.3).	0.1126 -	
	abt. 1 year later		Thallus with several bifurcations; 12.4 (2.0); near base 2 side shoots: 1.5 (0.2); 1.3 (0.1).		
	abt. 2 years later		Greater part of a dead; new basal shoots appeared; the longest 6.6 (0.7).		
6	$^{5}/_{11}$ 32	Below 1 year	a: 1.7 (0.4); b: 0.8 (0.1); c: 0.3 (0.1); d: 0.2 (0.1).	0.0078 -	
	abt. 1 year later		a: several bifurcations; 7.0 (0.8); b: 3.3 (0.5); c: 3.2 (0.3); d: 2.6 (0.3); e: 2.0 (0.3); f: 1.6 (0.2). Further a few tiny shoots.		

Experimental plant no.	Date of observation	Approximate age at beginning of experiment	Description of the plant	Weight in air-dried condition	Weight increment during last year
	abt. 2 years later		a: 4 bifurcations; 12.3 (abt. 1.0); b: dead; c: bifurcate; 4.6 (0.6); d: 4.9 (0.7). — Further basal and side shoots.		
8	$^{5}/_{11}$ 32	Below 1 year	a: 1.2 (0.3); b: 0.3 (0.1); c: 0.3 (0.1).	0.0055 g.	
	abt. 1 year later		a: 5.3 (0.5) with small shoot near base: 0.3 (0.1); b: 3.0 (0.3); c: 1.8 (0.2); d: 1.1 (0.1). Further 2 small shoots, abt. 0.2.	0.047 -	0.0415 g.
	abt. 2 years later		a: dead; b: several bifurcations; 9.3 (0.8); c: dead; d: upper part devoured; e: 3.0 (0.5); f: 3.0 (0.4). — Further small basal- and side shoots (Fig. 2 a).	0.1357 -	
10	$^{5}/_{12}$ 32	—	Undivided thallus 0.7 (0.25).	0.0021 -	
	abt. 1 year later		2.6 (0.35). Further several small side shoots.	0.0083 -	0.0062 -
11	$^{5}/_{12}$ 32	—	Undivided thallus 1.2 (0.25).	0.0043 -	
	abt. 1 year later		a: several bifurcations; 4.3 (0.25); b: 0.5 (0.05); c: 0.4 (0.05).	**0.0238** -[1])	0.0195 -
12 b	$^{1}/_{6}$ 33	—	Undivided thallus 1.0 (0.1).	0.0018 -	
	abt. 1 year later		a: 4.6 (0.65); b: 0.7 (0.1). Further small basal and side shoots.	0.0404 -	0.0386 -
14	$^{5}/_{12}$ 32	—	Undivided thallus 2.8 (0.8).	0.0262 -	
	abt. 1 year later		a: several bifurcations (one branch dead); 10.5 (0.9), with 2 air vesicles; b: 3.1 (0.3); c: 3.0 (0.3). Further many basal and side shoots.		
16	$^{19}/_{12}$ 32	—	Undivided thallus 1.1 (0.3).	0.0042 -	
	abt. 1 year later		a: 5.4 (0.5); b: 0.7 (0.1); c: 0.5 (0.05); d: 0.4 (0.05).	0.0458 -	0.0416 -
	abt. 2 years later		a: 12.0 (0.85); b: 4.3 (0.5); c: 3.2 (0.25). Further small basal and side shoots (Fig. 2 b).	**0.2547** -[1])	0.2089 -
17	$^{19}/_{12}$ 32	—	Undivided thallus 1.1 (0.3).	0.0042 -	
	abt. 1 year later		5.3 (0.6).	0.0451 -	0.0409 -
	abt. 2 years later		a: 9.7 (0.8); b: 2.3 (0.3).	0.1394 -	0.0943 -
18	$^{19}/_{12}$ 32	—	Undivided thallus 2.2 (0.5).	0.0116 -	
	abt. 1 year later		a: several bifurcations; 8.4 (0.75); with two side shoots: b: 1.3 and c: 0.9. At base further 8 small linear shoots.	0.1683 -	0.1567 -
	abt. 2 years later		a: 3 bifurcations (one branch devoured), 14.7, with 4 air vesicles; b: 5.7 (0.4); c: bifurcate, 4.5 (0.4); d: 4.0 (0.35). Further many basal and side shoots (Fig. 2 c).	**0.5670** -[1])	0.3987 -
19	$^{19}/_{12}$ 32	—	Undivided thallus 1.45 (0.35).	0.0063 -	
	abt. 1 year later		a: 4.8 (0.4); b: 1.9 (0.2); c: 1.2 (0.2).	0.0355 -	0.0292 -
	abt. 2 years later		a: bifurcate, 8.7 (0.6), one branch with small air vesicle; b: bifurcate, 5.6 (0.45); c: 4.8 (0.4). Further basal and side shoots.	0.1983 -	0.1628 -
	abt. 3 years later	—	a: several bifurcations, 12.3 (0.6); b: several bifurcations, 9.0 (0.45); c: bifurcate, 9.6 (0.5); d: 8.6 (0.5). Further basal and side shoots (Fig. 2 e).	**0.4414** -[1])	0.2431 -
20	$^{12}/_{1}$ 33	—	Undivided thallus 2.6 (0.9).	0.0252 -	
	abt. 1 year later		Thallus bifurcate: 7.6 (1.0);	0.104 -	0.0788 -
	abt. 2 years later		a: several bifurcations; 13.4 (1.0); b: 2.2 (0.4). Further small side shoots.	0.3615 -	0.2575 -
21	$^{12}/_{1}$ 33	—	Undivided thallus 2.4 (0.5).	0.016 -	
	abt. 1 year later		a: 5.8 (0.5); b: 0.5 (0.1).	0.0445 -	0.0285 -
	abt. 2 years later		a: 9.8 (0.7); b: 2.1 (0.2). Further small side shoots (Fig. 2 d).	**0.0678** -[1])	0.0233 -
22	$^{12}/_{1}$ 33	—	Undivided thallus 1.8 (0.3).	0.0057 -	
	abt. 1 year later		4.6 (0.4).	0.02 -	0.0143 -

[1]) The weighings of plant no. 11 after 1 year, of no.s 16, 18, and 21 after 2 years and of no. 19 after 3 years were carried out: for no. 11 on 22-II-34, for no.s 16, 18, and 21 on 28-II-35, and for no. 19 on 28-XI-35. So the weight increment of the last year was in these cases not based on the growth of one twelvemonth, but of $14^{1}/_{2}$ months for no. 11, $14^{1}/_{3}$ months for no.s 16 and 18, $13^{1}/_{2}$ months for no. 21, and $11^{1}/_{3}$ months for no. 19. — But as only an approximate value for the annual production is aimed at, the error arising in this way cannot be of any great importance, particularly not because the additional (or wanting) time occurs during the dark period with its very inconsiderable growth and production of matter.

lower part *Rhodymenia palmata*. On the lower part of Drogden 2 and its mooring chain *Chorda tomentosa* was growing.

The zone of green algae in the water-line showed the highest development on Drogden 2 but was rather heterogenous on the different sides of the buoy. Material mowed from an area of 21 × 21 sq. cms. = 441 sq. cms. on this buoy, which had been put out on 12-IV-34, had a weight of 4.9525 gms. (the plants dried in the air), corresponding to 112.3 gms. per 1 sq. m. The principal part of the sample consisted of *Acrosiphonia*, *Enteromorpha*, and *Cladophora*, intermixed with *Ilea* and *Scytosiphon* (and a few seedlings of *Fucus*).

B. The production of matter in *Fucus vesiculosus* at the Saltholm.

Besides knowing the total production of a given area (1 sq. m.) in a given time it would be worth learning the annual yield of the individual species among the large producers. For the purpose of determining the annual production of *Fucus vesiculosus* I started an examination on the Saltholms Flak in the autumn of 1932. During the time passed since that date 20 plants (see fig. 2), growing on stones at depths of $^1/_2$—1 m., were controlled, and at certain intervals (to begin with about 14 days) they were measured (length and breadth) and described. When the thallus of some plant showed a bifurcation during its growth, I also measured the length from the base of the plant to the point of division, as well as the length and breadth of the new shoots. In weighing a plant corresponding exactly to a given experimental plant at the beginning of the experiment we will most likely get an approximate expression of the weight of the experimental plant at this time, at any rate if the weight of the substitute is calculated as the average of the weight of several plants. In the same way we can get an efficient expression of the weight of the experimental plant 1 and 2 years after the beginning of the experiment. — The survey on pp. 44—45 (Table 4) shows the preliminary results. The figures given for weights of material dried in the air were in most cases calculated as the average of 5 plants of the said appearance. The black figures of this column denote that the weight stated originates from weighings of the experimental plants themselves (11, 16, 18, 19, and 21). The right-hand column gives the weight increase of a given experimental plant within the last year. In the column "Description of the plant" we find a short description of the appearance of the experimental plants at the beginning of the experiment, 1 year later, 2 years later, and, in the case of plant no. 19, 3 years later. When the thallus consisted of several shoots, the latter are characterized as a, b, c, . . ., a meaning the longest, b the second longest shoot, etc. When a shoot showed one or several bifurcations, only the distance from the base to the point of the longest branch is stated. The bracketed figures denote the breadth, measured in the broadest place.

Fig. 2 a. *Fucus vesiculosus* from the Saltholm. — Experimental plant no. 8, 28-II-1935. Also shoot b has now partly been devoured. Age about 3 years. Natural size.

Fig. 2 b. *Fucus vesiculosus* from the Saltholm. — Experimental plant no. 16, 28-II-1935. Age about 3 years. Natural size.

Of course we would not expect to find a direct correspondence between the total surface of a plant and its weight. The thallus of some plants are thicker than that of others, the greatest variations of thick-

ness being found in the mid-rib. The total surface is in some plants to be calculated from one, in others from several shoots.

It appears from Table 4 that at the beginning of the experiment the average weight in an air-dried condition of the plants 8, 10, 11, 12b, and 16—22 was 0.0079 gms.; at this time all these plants were most likely less than one year old. After 1 year the average weight of the same plants was 0.053 gms., which gives an average increase of 0.0451 gms. After the course of 2 years the average weight of the plants 16—21 was 0.2648 gms.: the average weight of these plants after 2 years is consequently 0.2118 gms. higher than the average weight of the plants 8, 10, 11, 12b, and 16—22 after 1 year. If we only look at the plants 16—21, the weights of which are stated from both the first and second year of experiment, we find the

average weight at the beginning of the experiment	0.0113 g.
average weight after 1 year ...	0.0739 -
— — after 2 years...	0.2648 -

So we find the average weight increase during the first year of experiment to be 0.0626 gms., during the second year 0.1909 gms. During the first year of experiment plant no. 19 increased its weight by 0.0292 gms., during the second by 0.1628 gms., and during the third year by 0.2431 gms.

Fig. 2c. *Fucus vesiculosus* from the Saltholm. — Experimental plant no. 18, 28-II-1935. Age about 3 years. Natural size.

Fig. 2d. *Fucus vesiculosus* from the Saltholm. Experimental plant no. 21, 28-II-1935. Age about 3 years. Natural size.

C. The growth of *Fucus*.

a. Seedlings.

The growth of seedlings of *Fucus* in Danish waters is dealt with in Table 5. Most of the sizes given are based on observations from the experimental blocks of concrete already mentioned, and so the time of exposure can only stand for the theoretically highest age of the plants in question. The plants may have settled on the blocks a shorter or longer time after the latter were put out. By way of instance may be mentioned that a concrete block put out on April 22nd, 1935 at Vorsø in the Horsens Fjord did not show any macroscopically visible vegetation on June 16th. On August 26th, however, it displayed an ample vegetation, more particularly of seedlings of *Fucus vesiculosus*; the largest specimens were 2.6 cms. long and 0.6—0.7 cm. broad. No doubt all specimens from the Sound and the Horsens Fjord are seedlings of *Fucus vesiculosus*, but some of the specimens from the Great Belt and the Little Belt are possibly seedlings of *F. serratus*.

b. *Fucus vesiculosus*.

It appears from Table 4 that the growth increase in the experimental plants of *Fucus vesiculosus* on

Fig. 2 e. *Fucus vesiculosus* from the Saltholm. — Experimental plant no. 19, 28-XI-1935. Age about 4 years. Natural size.

the Saltholms Flak is exceedingly small. In the shoot a the annual length increase generally ranges between 3 and 6 cms., that is an average of 1 cm., in 2—4 months. On the whole the increase during the second year after the beginning of the experiment does not seem to be very much larger than during the first year. During the second year of experiment, however, the shoot a of several plants has divided once or several times (in some plants already during the first year of experiment). Of course the growth varies at the different seasons of the year, being more rapid during the light than during the dark season. In Table 6 is given a survey of the average monthly growth increase of the shoot a during respectively the dark (October, 1st —April, 1st) and the light season (April, 1st —October, 1st).

It appears from this survey that the average monthly length increase of the plants 1, 3—10, and 14—22 during the dark season of the second year of experiment was 0.21 cm., 0.55 cm. for the plants 1 and 3—22 during the light season of the first year of experiment, and 0.65 cm. for the plants 1, 3, 6, 16, and 18—21 during the light season of the second year of experiment. If we look at the plants 6—22 only, none of which were more than 1 year old at the beginning of the experiment, we find that the average monthly length increase

Table 5. Synopsis of the growth in seedlings of *Fucus*.

	Locality	Time of exposure		Maximum size
The Sound	Saltholms Flak, 1 m	$^{13}/_{11}$ 33—$^{18}/_{10}$ 34 = abt. 11 months		1.2—1.6 cm (breadth: 0.1—0.15 cm).
	—	$^{28}/_{10}$ 34—$^{28}/_{9}$ 35 = 11	-	4.0—4.7 cm (0.4—0.5 cm) (Fig. 4).
	Drogden (Light-buoy »Drogden 2«)	$^{12}/_{4}$ 34—$^{14}/_{5}$ 35 = abt. 13	-	2.0 cm (0.5 cm), 1 individual.
Great Belt	Nyborg Fjord, 1 m	$^{25}/_{3}$ 33—$^{28}/_{10}$ 33 = abt. 7	-	3.0—4.3 cm (0.6—0.7 cm); 1 plant 5.9 (0.6). Average abt. 2 cm.
	—			
Little Belt	Geerhagen at Fænø, 1 m	$^{24}/_{3}$ 33—$^{27}/_{10}$ 33 = abt. 7	-	2.4—3.7 cm (up to 0.7 cm). Average 1.5 —2.0 cm.
	—			
	—	$^{15}/_{4}$ 35—$^{22}/_{8}$ 35 = abt. $4^{1}/_{4}$	-	1.2 cm (0.2).
	Fænø Kalv, 3 m	$^{24}/_{3}$ 33—$^{27}/_{10}$ 33 = abt. 7	-	3.0—3.6 cm.
	—	$^{27}/_{10}$ 33—$^{23}/_{7}$ 34 = abt. 9	-	6.1 cm (1 individual).
Horsens Fjord	Vorsø, 0—$^{1}/_{2}$ m	$^{22}/_{4}$ 35—$^{26}/_{8}$ 35 = abt. 4	-	2.6 cm (0.6—0.7 cm).
	—	$^{22}/_{4}$ 35—$^{15}/_{9}$ 35 = abt. $4^{3}/_{4}$	-	2.8—3.5 cm (0.7—0.9 cm).
	—	$^{16}/_{6}$ 35—$^{15}/_{9}$ 35 = abt. 3	-	2.5—3.1 cm (0.5—0.7 cm) (Fig. 3).
	Vorsø, $1^{1}/_{2}$ m	$^{22}/_{4}$ 35—$^{15}/_{9}$ 35 = abt. $4^{3}/_{4}$	-	2.5—2.9 cm (0.6—0.8 cm).

Table 6. Synopsis of the growth in shoot a of the experimental plants of *Fucus vesiculosus* on the Saltholms Flak.

Experimental plant	Average increment per month during dark season ($^1/_{10}$—$^1/_4$)[1] 1. year of exp.	2. year of exp.	Average increment per month during light season ($^1/_4$—$^1/_{10}$) 1. year of exp.	2. year of exp.
1	0.24 cm	0.3 cm	0.52 cm	0.43 cm
2	0.21 -	..	..	..
3	0.17 -	0.37 -	0.67 -	0.8 -
6	0.14 -	0.13 -	0.70 -	0.73 -
8	0.12 -	0.03 -	0.58 -	..
10	0.08 -	0.07 -	0.27 -	..
11	0.08 -	..	0.42 -	..
12 b	0.15 -	..	0.62 -	..
14	0.28 -	0.33 -	0.97 -	..
16	0.15 -	0.28 -	0.52 -	0.88 -
17	0.15 -	0.32 -	0.48 -	..
18	0.27 -	0.28 -	0.70 -	0.73 -
19	0.15 -	0.18 -	0.38 -	0.50 -
20	..	0.15 -	0.71 -	0.68 -
21	..	0.17 -	0.42 -	0.47 -
22	..	0.10 -	0.33 -	..
Average	..	0.21 -	0.55 -	0.65 -

[1]) For the dark season of the first year of experiment the average monthly growth increment has not been calculated on the basis of the period $^1/_{10}$—$^1/_4$ (apart from plante 12b), but from the beginning of the various experiments until $^1/_4$, viz.: for plants 1, 2 and 3 from $^{20}/_{10}$, for plants 6 and 8 from $^5/_{11}$, for plants 10, 11 and 14 from $^5/_{12}$ and for plants 16, 17, 18 and 19 from $^{19}/_{12}$.

of 6—10 and 14—22 is 0.19 cm. during the dark season of the second year of experiment, 0.55 cm. for 6—22 during the light season of the first year of experiment, and 0.67 cm. for 6, 16, and 18—21 during the light season of the second year of experiment.

Fig. 3. Seedlings of *Fucus vesiculosus* from Vorsø. — Maximum age about 3 months (Time of development 16-VI-35 to 15-IX-35 at most). Natural size.

On August 23rd, 1934, I collected some specimens of *Fucus vesiculosus* on the third bridge-pier of Lille Bælts Broen (the bridge across the Little Belt); the 17 largest individuals of this sample were 10.2—14.5 cms. long. Their age could not be more than 19 months because the pier had not been in contact

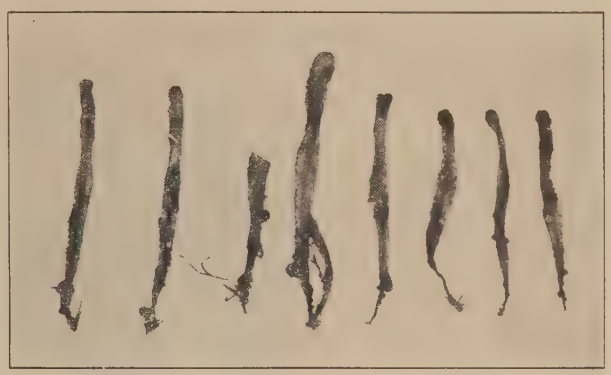

Fig. 4. Seedlings of *Fucus vesiculosus* from the Saltholm. — Maximum age 11 months (Time of development 28-X-34 to 28-IX-35 at most). Natural size.

with the water before January 28th, 1933. The longest individual, 14.5 cms. long, was 2.3 cms. broad: this is the highest breadth measured. The plants were vigorous and branchy, and several of them had minute air vesicles, but fructification organs did not occur (Figure 5). 1 year later, in 1935, some few of the largest intact individuals from this locality were about 25 cms. long. Several of the largest and most vigorous plants had lost their upper ends, but nevertheless they measured 23 cms. in length. A characteristic fact about the largest specimens collected in 1935 — as compared with the 1934 plants — was a conspicuous increase of thickness, more particularly in the mid-rib. Besides this the plants were far more branchy than in 1934, and many fresh shoots had appeared at the bases (Figure 6). But even now no fructification organs were found.

At Vorsø in the Horsens Fjord some individuals of *Fucus vesiculosus* were collected on October 14th, 1933 from a pole put out on September 17th of the previous year (highest age possible about 13 months); the largest plant was about 16 cms. long (Figure 7). Several individuals had a few air vesicles.

c. *Fucus serratus.*

Some individuals of this species were collected on August 22nd, 1935 from the third bridge-pier of Lille Bælts Broen. The largest of the plants, all of which had been exposed to most rapid currents, were 37—51 cms. long; none of them were more than $2^1/_2$ years old (Figure 8).

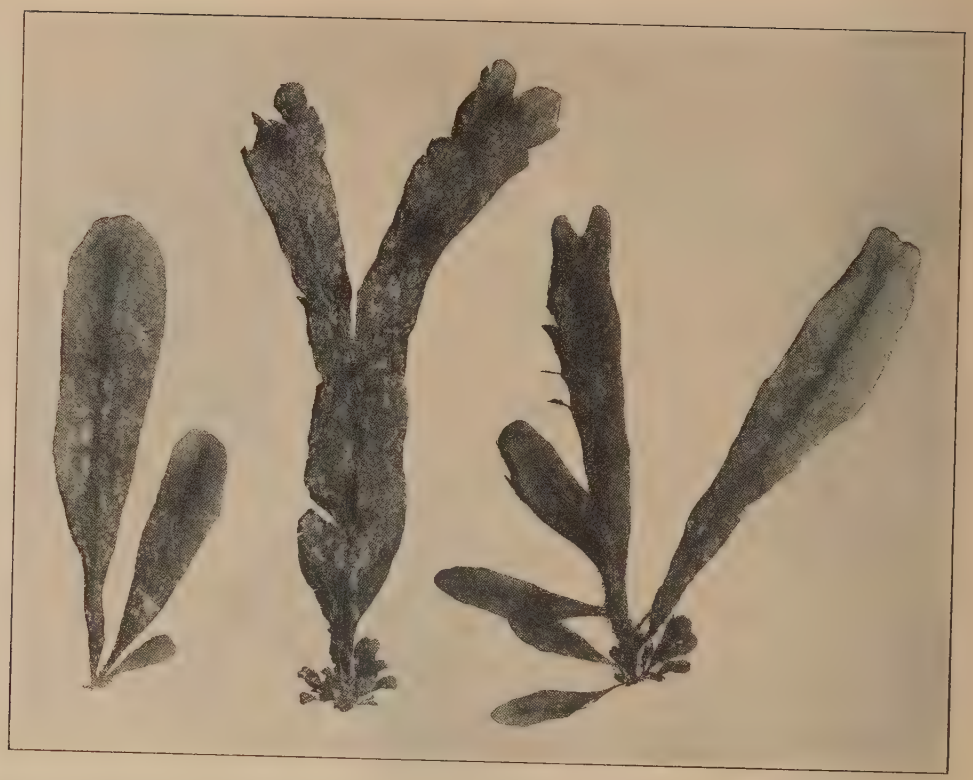

Fig. 5. *Fucus vesiculosus* from Lille Bælts Broen. Maximum age about 19 months (time of development 28-I-33 to 23-VIII-34 at most). — $^{2}/_{3}$ nat. size. — NB: adherent animals and plants removed.

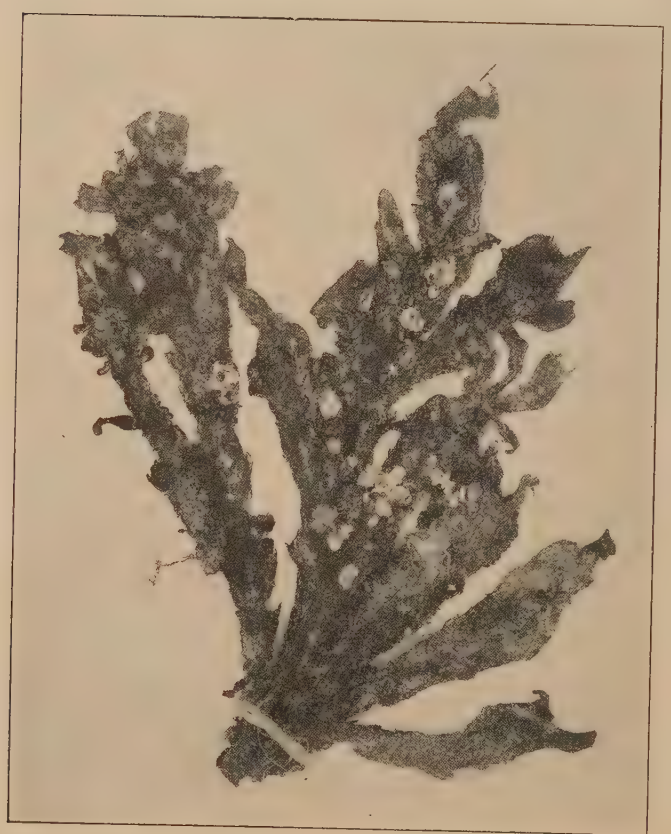

Fig. 6. *Fucus vesiculosus* from the same locality. Maximum age about 31 months (time of development 28-I-33 to 22-VIII-35). $^{3}/_{8}$ nat. size.

Fig. 7. *Fucus vesiculosus* from Vorsø. Maximum age about 13 months (time of development 17-IX-32 to 14-X-33 at most). $^{2}/_{3}$ nat. size.

Fig. 8. *Fucus serratus* from Lille Bælts Broen. Maximum age about 31 months (time of development 28-I-33 to 22-VIII-35 at most). — $^{3}/_{5}$ nat. size.

As regards the life duration of *Fucus* may be quoted the supposition advanced by Knight and Parke (1931, p. 15), viz. that the age does not exceed 2 or 3 years at the coasts of England. Kenneth Rees (1932, p. 1064) supposes the maximum age to be 4—5 years (average age of plants at places of mean exposure: 3—4 years). At Helgoland (Nienburg 1930, p. 9) *Fucus* will generally die in its 4th year of life.

At the Saltholm in the Danish waters *Fucus* seems to grow much older. However, the life duration of a species will depend on various conditions, and so we must suppose it to be rather different at different localities; among other things the growth rate and the exposure of the place will be of importance. Also the growth rate depends on many factors, as for instance the salinity of the water and its contents of nutritive matter, fluctuations of salinity and temperature, renewal of water, conditions of light, and exposure of the locality. Most likely the slow growth rate at the Saltholm is principally due to the rather large fluctuations of the salinity of the surface water.

I am much obliged to Dr. H. Blegvad who most kindly photographed all the plants figured.

October 1st, 1935.

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